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INTERNATIONAL APPLICATION PUBLISHED UNDER T

WO 9608295A1

(51) International Patent Classification 6 : A63F 1/18 A1

(11) International Publication Number: WO 96/08295

(43) International Publication Date: 21 March 1996 (21.03.96)

(21) International Application Number: PCT/US95/11658

(22) International Filing Date: 15 September 1995 (15.09.95)

(30) Priority Data:
08/307,282 16 September 1994 (16.09.94) US

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(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).

Published

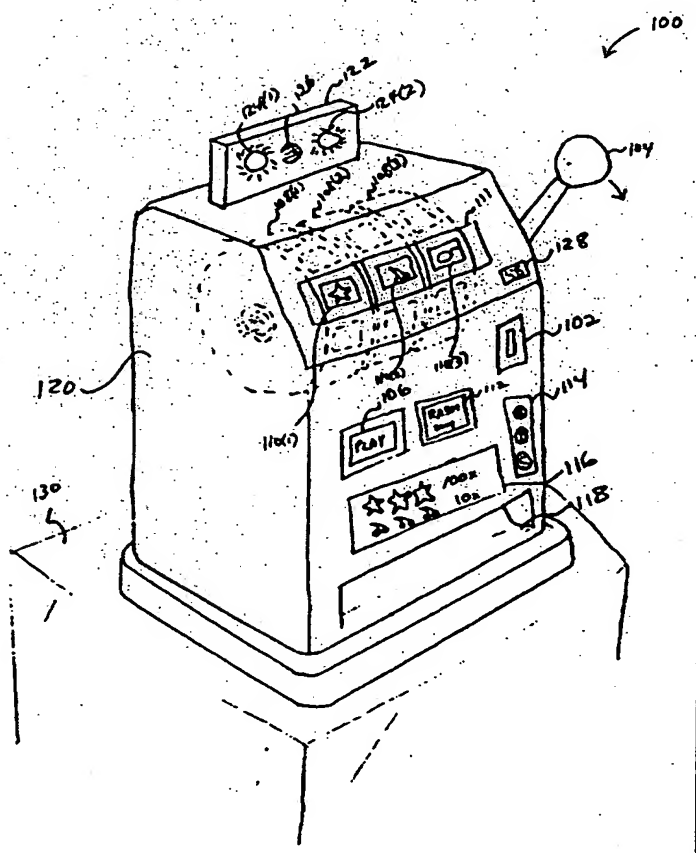
With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: ELECTRONICALLY-CONTROLLED GAMING MACHINE WITH INDEPENDENT OUTCOME SELECTION

(57) Abstract

A gaming machine (100) is provided with various modules which together form a distributed processor control system for the gaming machine. Each module communicates synchronously with other modules over a bus (5, 16). When used with a mechanical reel slot machine, a pull handle (104) activates a game, and the reels are controlled by stepper motors (302) to create the appearance of a mechanical linkage. During the play of the game, the stepper motors (302) rotate the reels and cause them to slow down and stop at the symbol combination of the selected outcome, to simulate the frictional slowing of reels in a mechanical slot machine where the stopping position of the reels is determined by frictional forces. A game processor (502) determines the outcome. The probability of a given payout is independent of the distribution of symbols on the reels, so a player can be provided a choice of different payout tables. In one embodiment, the game processor (502) may generate a random number to determine if a hit has been made (906). If a hit was made, a second random number may be generated to select a payout from a payout distribution (912). A third random number may be generated to select a consistent display based on the payout distribution (916).



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ELECTRONICALLY-CONTROLLED GAMING MACHINE WITH INDEPENDENT OUTCOME SELECTION

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CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of Application Serial No. 08/162,501 filed December 3, 1993, which is incorporated herein by reference for all purposes.

BACKGROUND OF THE INVENTION

This invention relates to gaming machines and more particularly to slot machines, which are gaming machines wherein a game outcome is indicated by the symbols on a set of reels appearing in a window, either using mechanical reels or electronically simulated reels.

The operation of gaming machines vary, but have several common characteristics, such as that a player makes a wager, and either the wager or the player initiates a game. When the game ends, the gaming machine displays a final result and provides a payout amount. For losing games, the payout amount is usually zero. A payout defines a payout amount or payout-to-wager ratio and a probability of occurrence. The resulting display and payout are collectively referred to herein as the game outcome.

The casino business is very dynamic. Typically, a casino operates many gaming machines and offers many different varieties of machine on its gaming floor. A modern casino is usually set up to determine on a weekly, daily, or even hourly basis, which machines are being played more often than others, using automated monitors or well-placed observers. Because the revenues of a casino are determined by how many players are using their machines, and how much they are playing, a casino would like all players in the casino to be able to play a machine of their choice. Consequently, a casino would rather replace an unpopular machine with a popular one than have players constantly waiting to play a popular machine.

Therefore, to have as many simultaneous players using the available machines, a casino must be able to easily change the distribution of machines on its floor. However, this capability has been quite costly for casino operators, since it requires the casino operator to maintain a large number of unused machines in reserve to swap in when they become more popular than the machines currently on the gaming floor. One example is video slot machines and mechanical reel slot machines. If the video slot machines are relatively unpopular compared to mechanical slot machines, the adept casino operator will adjust the proportion of machines on the gaming floor to ensure that more mechanical slot machines are available for play than video slot machines.

Other factors which affect the popularity of the games relate to its payout characteristics, in particular, the hit frequency, the hold percentage and the payouts.

Hit frequency is the frequency with which a game results in a winning game. This is a probability, so it is usually expressed as a percentage or as a fraction or decimal number between 0 and 1. By adjusting the hit frequency, the casino operator can modify the appeal of a game. For example, with a hit frequency of 5%, a player is likely to lose nineteen out of twenty games, and this can be quite discouraging. However, with a high hit frequency, such as 40%, a player will win more often. Of course, the amount a casino will pay out for each win is less if the wins occur

more frequently, since a casino expects not to pay out more than it takes in. The hit frequency is equal to one minus the probability of a losing game.

The hold percentage is the percentage of the money wagered which the casino operator expects to keep (or pay out if this number is, for whatever reason, negative). One minus the hold percentage of a particular game is the game's return, i.e., what ratio of the amount wagered is returned to the player on average. For example, a machine with a hold percentage of 6% can be expected in the long run to pay out 94% of what it takes in, leaving 6% for the casino operator. Thus, on average, a player playing 100 games, wagering one coin per game, can expect to receive 94 coins. Of course, in the short run, some players will win more than wagered and some players will win less than 94% of the amount wagered. The return affects the popularity of a game, and often casinos will advertise their return percentage as a way to get customers into their casinos.

The hit frequency, return and payouts are referred to herein collectively as the payout table, which is a table of the possible payout amounts and their probabilities. The payout table includes a losing game as a payout having a payout amount of zero and a probability of occurring equal to one minus the hit frequency. In a payout table, the sum of the probabilities of all the payouts is one and the sum of the amounts of each payout weighted by its probability is the return.

In a typical machine, the player wins coins, tokens, or other indicators of value, equal to the payout amount times the wager, and the payout amount and wager need not be the same type of value indicator.

With all other things being equal, a machine with a higher return will be more popular, and a machine with a higher hit frequency will be more popular. However, an interest in increasing a machine's popularity must be balanced against the need for a casino to turn a profit on the gaming machines. In order to respond quickly to differing customer desires, a casino operator needs to be able to adjust the

payout characteristics for each of its machines, as well as to adjust the distribution of machine types placed on the gaming floor.

Historically, slot machines were mechanical reel machines. In a mechanical reel machine, a number of reels are provided each having a number of stopping positions, with a symbol displayed in a symbol window for each stopping position. The symbol window allows the player to see the symbols associated with the stopping positions, and also allows the player to see the other symbols on the reels as the reels are spinning before they stop at their stopping positions. A typical machine has three reels, with twenty stopping positions on each reel, each stopping position being equally likely. The symbols at the stopping positions might be easily recognizable fruits, such as cherries and plums, or shapes, such as stars and bells, or abstract symbols such as "7", "JACKPOT", or "BAR". The symbols need not be equally likely, even if the stopping positions are equally likely, since several stopping positions can have the same symbol associated with it. If symbols are repeated on a reel, then the number of different final displays will of course be less than the number of different stopping position combinations.

In prior art mechanical reel machines, the game outcome is determined by the stopping positions of the reels. The final display is the combination of symbols shown in the symbol window when the reels have stopped, and the payout amount is determined according to payout rules. The payout rules for a game might dictate that a player wins 2 times the wager if the final display is two cherry symbols appearing in the window and wins a thousand times the wager if the final display is three star symbols. Since the distribution of symbols on the reels is known, and each stopping position is equally probable, the probability of each payout is easily calculated.

Using basic probability theory, a casino operator can determine the hit frequency and return for a machine from the distribution of symbols and the payout rules. In fact, given the payout rules, the distribution of symbols determines

the entire payout table. For the three reel, twenty position machine described above, there are 8000 (20 * 20 * 20) different stopping position combinations, all equally likely (barring illegal manipulation of the machine or malfunction). Suppose for the simplicity of the example, that each reel is provided with a single star symbol, five cherry symbols and fourteen symbols which do not contribute to any winning combination. Further suppose that the payout rules are as follows: a player wins 2000 times the wager for three stars and 10 times the wager for three cherry symbols. Since the distribution of symbols on the reels and the payout rules determine the payout table, the hit frequency and the return for this game are determined by the machine. The probability of getting three stars is one in 8000 (or .0125%) and the probability of getting three cherry symbols is one in sixty four (125/8000, or 1.5625%), so the hit frequency is about one out of sixty three games ([125+1]/8000, or 1.575%) and the return is about 40% ([[125*10]+[1*2000]]/8000). With this hit frequency and return, the machine is not likely to be popular, so different reels or different symbols sets should be used, or the payout rules should be changed.

In some cases, a casino operator, or slot machine manufacturer, could replace the reels associated with one payout table with another set of reels to adjust such payout factors as the hit frequency and return. Alternatively, the symbols on the reels could be made to be changeable. The payout rules could also be changed, but since the winning symbol combinations and their payout amounts are customarily posted on the machines, this is more difficult.

Often in some machines, the stopping positions were not all equally probable, either due to malfunction, wear, or manipulation by unscrupulous players shaking the machine or using magnets to make winning positions more probable. One attempt to solve this problem is shown in U.S. Patent No. 4,095,795 issued to Saxton et al. In a Saxton machine, following the pull of an arm or the press of a game start button, a computer simulates the rotation of the reels and uses a random number to determine the stopping position of the

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simulated reels. The computer then controls the physical reels so that they stop at the positions determined by the simulated rotation. Because the stopping position of the reels is determined by a simulated rotation of the reels, a casino operator is assured that the payout characteristics will not vary from the payout characteristics dictated by the payout rules and the distribution of symbols on the reels; however, the casino operator is also not able to change these characteristics when desired.

One problem with mechanical reel machines and simulated mechanical reel machines is that the hit frequency and the return are limited by the distribution of symbols on the reels. In the above example, each of 8000 outcomes were equally likely. Therefore, a casino cannot offer a payout amount of 10,000 times a wager and still have a return of less than 100%, because the lowest probability for a particular combination of symbols is 1 in 8000 with a three reel, twenty position slot machine. In fact, the probability of any winning combination cannot be set to other than an integer multiple of 1/8000.

One slot machine, described in U.S. Patent 4,448,419, issued to Telnaes, uses virtual reel expansions to achieve lower probabilities than would be allowed by the physical reels used. In the Telnaes machine, the rotation of the reels is simulated, but the simulated reels contain more positions than the physical reel. To do this, some positions on a physical reel are mapped onto more than one position on the simulated reel. However, the hit frequency and return are still dependent on the simulated reels used. Therefore, in a dynamic environment, a casino operator would have to shut down a machine and replace its simulated reel strip to effect a different hit frequency and return. This is equivalent to a mechanical reel machine where some stopping positions are more likely by an integer multiple of the probability of other stopping positions occurring.

In a video gambling game, such as a video slot machine, the stopping positions are determined by simulating mechanical reel machines, as in the Saxton machine. In some

environments, mechanical slot machines are more popular, in that they provide a player with a feel for an older mechanical reel machine, even if the outcomes are in reality determined by a computer.

One mechanical slot machine, described in U.S. Patent No. 4,573,681, issued to Okada, even goes so far as to simulate a player's ability to stop the reels at particular symbols. In an Okada machine, a computer uses a random number generator to determine a tentative payout amount. The machine spins the reels, and the player is allowed to press a button to stop each reel. When the button for a reel is pressed, the computer determines which symbol is in the window and decides whether that symbol will allow for the tentative payout amount. If it is, the reel is stopped on that symbol. If it is not, the reel is stopped on a nearby symbol. Although a player appears to be able to control the payouts, the actual return and hit frequency are fixed.

The theory of this machine is that a player will not notice that his or her chosen symbol is not actually being selected if a symbol within four symbols of the chosen symbol is selected. Instead, the player will attribute the wrong symbol being selected to pressing the button too soon or too late. In some cases, especially with the last reel, none of the nearby symbols will allow the tentative payout amount, and the machine is forced to pay out a different payout amount. In these cases, a payout consistent with the actual stopping positions of the reels is made and a bias is applied to the next game which is related to the difference between the tentative payout amount and the amount actually paid out. In this manner, the slot machine can maintain a pre-set return even though the player appears to have control over where the reels stop.

Gaming machines must also be easy to maintain, and given that gaming regulations change from time to time, casino operators need inexpensive ways to modify their existing machines to comply with new regulations.

One common maintenance problem with slot machines is the alignment of the reels. If a reel contains twenty

symbols, then a full reel is divided into 18 degree segments associated with each symbol. When a reel stops, one of those 18 degree segments should be centered in a viewing window which shows the final display. If the reels are not properly aligned, then a reel may stop such that half of each of two symbols will appear where a single, whole symbol should appear. On solution to the need for alignment of symbols is shown in U.S. Patent 5,102,136, issued to Heidel et al., in Figure 5 and column 4, lines 38-62 therein. That solution comprises a screw for adjusting the rotational position of a reel support which in turn adjusts the rotational position of the symbols on the reels supported by the reel support. However, is a complicated mechanical alignment mechanism and it relies of maintaining alignment between the symbols on the reels and the reels support.

SUMMARY OF THE INVENTION

The foregoing difficulties have been solved by the gaming machine according to the present invention described herein. In one embodiment, a gaming machine comprises various modules, such as a value acceptor for accepting coins, bills, tokens, or other indications of value which serve as wagers, a game start switch in the form of a push button or a pull arm, a game processor for determining the payout of a game and a final display consistent with that payout, a game display for displaying the final display at the end of a playing period, and a payout mechanism to provide indications of value to winning players, all enclosed within an enclosure which prevents unwanted manipulation. Each module is controlled by a separate processor, with well-defined interfaces between the modules. For example, if the gaming machine is a slot machine, each reel of the slot machine might be controlled by a reel processor which communicates with the game processor.

The use of a distributed processor system within a slot machine allows for synchronous events to occur without interrupting other processes which may be occurring, and also allows modules to be independently replaced, thus saving a casino operator considerable expense when the casino desires

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to replace a module, for maintenance, on the basis of feature popularity, or to comply with changing gaming regulations.

Furthermore, the modularity eliminates the need for all the modules to be in one location, and provides a manufacturer with a simple way to provide different variations of a machine for different jurisdictions. Other optional modules with their own processors include a light and sound processor and a network interface processor.

As an added advantage, illegal tampering with a gaming machine is made more difficult through the use of distributed processors, since a cheater would have to simultaneously disturb the operation of more than one processor, such as the reel processor and the game processor.

A particular embodiment of the invention is a mechanical reel slot machine with pull handle activation of a game. In this embodiment, the movements of the reels are controlled by stepper motors and the pull handle module includes a sensor to indicate when the pull handle is being pulled only slightly. When the pull handle is moved slightly, the stepper motors move the reels slightly, to suggest that a mechanical coupling exists between the pull handle and the reels. During the play of the game, the stepper motors rotate the reels and cause them to slow down and stop at the symbol combination of selected outcome, to simulate the frictional slowing of reels in a mechanical slot machine where the stopping position of the reels is determined by frictional forces.

With stepper motor control, the game processor can query the reel processor(s) to determine the orientation of the reels, and using a diagnostic system, a technician can direct the reel processors to step the stepper motors and record a position in order to align the reels such that symbols remain centered on a symbol display window.

Because the game processor determines the outcome of a game, and the probability distribution of payouts is independent of the distribution of symbols on the reels, a player can be provided a choice of different payout tables, such as a payout table that favors intermediate wins over big

wins or a payout table with only big wins. In one particular embodiment, the payout table changes based on patterns of play. For example, the slot machine might use several payout tables during several test periods and note which payout tables result in the most play, or keep one player at the machine the longest. The length of time a player is at a machine can be guessed with reasonable accuracy from the timing of gaps between the end of a game and the start of the next game, as the gaps are generally longer between players than between two games played by the same player.

Additionally, the hit frequency and return can be manipulated by a machine owner/operator for a series of games or each game, while still allowing a random determination of a payout and a final display for any given game.

A further understanding of the nature and advantages of the inventions herein may be realized by reference to the remaining portions of the specification and the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a simplified perspective view of a slot machine according to the present invention;

Figure 2 is a simplified perspective view showing the handle mechanism of the slot machine in further detail;

Figure 3 is a front view of a slot machine reel, and associated hardware and circuitry;

Figure 4 is a side view of a slot machine reel showing its decoder ring and symbol sector and step divisions

Figure 5 is a schematic diagram of the distributed processors of a slot machine;

Figure 6 is a board layout diagram of the electronic circuitry used to support the operation of the slot machine;

Figure 7 is a schematic diagram showing the game processor in further detail;

Figure 8 is a flowchart of a process implemented by a game processor of the slot machine; and

Figure 9 is a flowchart of an alternate process implemented by a game processor.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is not so constrained, but is described herein with reference to one very specific example of a gaming machine which is a slot machine with three reels, each reel having twenty stopping positions, each of which has associated with it a symbol. Of the twenty symbols on a reel, one is a bar symbol ("BAR"), three are cherry symbols ("CHERRY") and sixteen other symbols which do not contribute to a winning display. In an actual machine, the symbols and payout rules are likely to be more varied, to keep the interest of players, however this example is simplified so that the description is clear. It should be apparent that the concepts disclosed herein apply to any slot machine configuration, and any gaming machine configuration where the result of a game is shown by a display and the display needs to be consistent with a payout determined randomly according to probability distributions and a desired return and/or hit frequency, especially where the display is a display of symbols, such as those found on reels of slot machines or poker cards in a poker gaming machine, and the desired return and/or hit frequency are independent of the distribution of the symbols.

Figure 1 is a perspective view of a slot machine 100 according to the present invention. Slot machine 100 is shown including a coin acceptor 102, a handle 104, a play button 106, three reels 108, each of which shows a symbol 110 in a symbol window 111. Slot machine 100 is also shown including a cash out button 112, a pay-out rules selector 114, a pay-out rule display 116, a hopper tray 118, and a top box 122, all either enclosed within a slot machine enclosure 120 or attached thereto. Top box 122 further comprises lights 124 and a speaker 126.

To begin a game, a player inserts a coin into slot 102. As should be apparent, wagers can be collected in different ways such as a bill acceptor, a token acceptor, a ticket acceptor or an electronic value transferring systems to transfer value from the player to the casino operator for a wager. Once a wager has been made, the player will pull

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handle 104 in the direction indicated or press play button 106. When a game is initiated, reels 108 are set in to rotation. A game processor (not shown) determines, as explained below, what the outcome of the game will be. This determination occurs on the basis of random number calculations and can complete before the reels begin spinning or may be performed after the reels begin spinning. The outcome of the game is a payout and a final display. The internal electronics of slot machine 100 cause reels 108, usually one at a time, to stop on the symbols selected as the final display. A payout amount is then ejected from a hopper (not shown) into hopper tray 118 and, depending on the payout amount, lights 124 may be set to illuminate or flash and speaker 126 may be controlled so as to emit sounds accompanying a winning payout. The final display and the payout which form the outcome of the game are selected so as to be consistent with payout rules as specified on payout rule chart 116. Payout rule chart 116 as shown in Figure 1 indicates that a final display of three star symbols will receive a payout amount of one hundred times the wager and a final display of three cherry symbols will receive a payout of ten times the wager. As explained below, selector switches 114 are used to select different payout probability distributions. The ability for a player to select different probability distributions or payouts is one advantage provided by the present invention as a byproduct of the fact that the payout distributions are not made dependent upon the payout rules combined with the distribution of symbols 110 on reels 108. Figure 1 does not show the various electronic controls which control the switches, lights 124, speaker 126, reels 108 and handle 104; however, these are shown in detail in Figures 5, 6 and 7.

Figure 2 shows control and sensor mechanisms associated with handle 104. Handle 104 exits enclosure 120 at a bearing 202 and extends into enclosure 120 as a shaft 208. Coupled onto shaft 208 are a position sensor 204, which in some embodiments is a potentiometer, and a lever arm 206 on which is attached a strain gauge 210. Position sensor 204

communicates a position signal to a handle processor over signal lines 214 and strain gauge 210 communicates a strain of lever arm 206 to the handle processor over signal lines 212.

Figure 2 also shows a blocking shaft 216 controlled by a solenoid 218 to either block lever arm 206 or allow lever arm 206 to be rotated up to microswitch 222, whereupon lever arm 206 causes the contacts of microswitch 222 to contact, sending a game trigger signal to the handle processor over lines 224. The handle processor also controls solenoid 218 over signal lines 226 to either allow handle 104 to be pulled or to prevent handle 104 from being pulled.

As should be apparent from Figure 2, if a user pulls handle 104 while blocking arm 216 is blocking lever arm 206, lever arm 206 will become strained and such strain will be detected by strain gauge 210 and a corresponding signal will be sent over signal lines 212. Supporting base 220 is shown supporting solenoid 218. Supporting base 220 is fixedly connected to enclosure 120.

Figure 3 shows the mechanisms associated with each of reels 108 in further detail, including a stepper motor 302, a stepper motor driver circuit 304, a reel processor 306, a shaft 308 used to communicate rotational motion from stepper motor 302 to reel 108, a zero-detect sensor 310, a zero-detect tab 312 positioned to rotate through gap 314 in sensor 310 and an optical sensor 316 positioned to detect optical variations on decoding reel 318. The operation of optical sensor 316 with decoding reel 318 is shown more clearly in Figure 4.

With this arrangement, reel processor 306 is able to control the position of reel 108 to a resolution of one step of stepper motor 302 and can also detect the position of reel 108 using a zero-detect signal obtained from sensor 310 and a current symbol detect obtained from optical sensor 316.

Figure 4 is a side view of reel 108 with divisions between symbols indicated. In an actual reel, these divisions may or may not be present. The arrangement of light and dark areas on decoder ring 318 are shown in greater detail for only one symbol segment, S4. This symbol-indicating pattern 402 comprises dark framing lines 406 and a dark square in the

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position designated with "4". Although it is not shown in Figure 4, each of the other segments of decoder reel 318 include patterns of light and dark spots separated by timing marks 406. The particular timing spots are indicative of the binary code for the number of the segment.

In this manner, reel 108 need be rotated through no more than one symbol segment to allow reel processor 306 to determine the position of reel 108. Should a power failure or malfunction occur such that reel processor 306 loses track of the position of reel 108, reel processor 306 need only send signals to stepper driver 304 to move reel 108 through the arc of a single symbol and reel processor 306 would then note the signal generated by optical sensor 316, convert it to a five-bit binary value, which would indicate which symbol segment is currently underneath optical sensor 316. Stepper marks 404 are also shown in Figure 4, although these are generally not included on the physical reel 108, but are shown in the figure to illustrate that stepper motor 302 is capable of stepping reel 108 through arcs much smaller than the arc defined by a symbol segment.

This ability is particularly useful when symbols 110 are not aligned in window 111. Using a diagnostic system, a technician can step reel 108 through a number of steps until symbols 110 are aligned in window 111. Once the reels are aligned, the diagnostic system notes the number of steps offset from a symbol sector boundary and provides that offset count to reel processor 306 and that count serves as an alignment offset, thus obviating the need for complex mechanical apparatus for keeping symbols aligned in window 111. Each reel processor maintains an alignment offset value for its reel.

Figure 5 is a schematic diagram of the distributed processors used to control various elements of slot machine 100. This is shown as distributed processor 500. Distributed processor 500 includes a game processor board 502, which is shown in greater detail in Figure 7, three reel processor boards which are discussed above in connection with Figure 3, a hopper processor 504, a door I/O processor 506, a handle

processor 508, a top box processor 510, a value acceptor processor 512, and an optional network I/O processor 514.

Each of these processors communicates with other processors over an RS485 bus 516. To communicate over the RS485 bus, one processor submits a message to the bus addressed to another processor in an asynchronous fashion. Because of this arrangement, each processor can perform its function without being interrupted by the events which may asynchronously occur on the inputs of other processors. For example, game processor board 502 accepts commands from a casino operator and also outputs a coin escrow display, while reel processor board 306 outputs stepper motor control signals and accepts zero detect signals and current symbol detect signals from reel sensors. The processing of zero detect signals and current symbol detect signals can be performed independent of the actions being performed by the game processor.

For security purposes, all messages on the RS485 bus are encrypted by the sender and decrypted by the receiver. Any number of encryption schemes can be used, such as a public key or a challenge-response encryption process which assumes that a undesired listener is monitoring all traffic on the bus.

Similarly, hopper processor 504 accepts inputs and provides outputs specific to the hopper, such as accepting a signal from hopper hardware indicative of the hopper being full and sending out signals to cause the hopper to release coins into hopper tray 118.

Door I/O processor 506 controls the door and security related functions as well as button sensing. Thus, the depression of payout distribution select button 114 and play button 106 are detected by door I/O processor 506. If slot machine 100 is provided with security devices such as door opening sensors and tamper detect sensors or tilt detect sensors, those inputs are provided to door I/O processor. Because of the distributed nature of the processors, it is much more difficult to fraudulently manipulate the internals of slot machine 100. In the prior art, where a single

processor is used to control all aspects of the machine, it would be a relatively simple matter for a cheater, once the slot machine door is open, to control the outputs of such a central processor.

Handle processor 508 controls all aspects of I/O with handle circuitry shown in Figure 2, such as an indication of the strain provided on lever 206, the position of the handle and an output to release the handle as well as a game start trigger provided by microswitch 222.

The present invention, handle processor 508 detects movement of handle 104 even where such movement may be less than the full travel of handle 104 and sends messages to reel processor boards 306 and reel processor boards 306 respond to such messages by sending stepper motor control signals to stepper driver 304 to move reels 108 slightly. This provides the apparent effect of handle 104 "jiggling" reels 108 as if they were mechanically coupled.

Top box processor 510 controls lights 124 and speaker 126 such that when game processor board 502 sends a payout message to top box processor 510, the top box processor will activate lights 124 and cause speaker 126 to emit sounds corresponding to the payout. For example, with a small payout, the lights might blink once or twice and with a large payout, the lights might flash repeatedly and a loud siren sound might be emitted from speaker 126.

Value acceptor processor 512 receives a signal indicating that a valid coin or other value indicator has been accepted as a wager and also controls value accepting mechanisms to prevent value from being accepted in such cases where hopper processor 504 has sent a message indicating that the hopper is full or game processor 502 has sent a message indicating that slot machine 100 has malfunctioned.

Another example of processor-to-processor communication is where a player presses cash-out button 112. Pressing button 112 causes a signal to be sent to door I/O processor 506 which debounces the button signal, if necessary, and packages a message to be sent over bus 516 to game processor board 502. When the message is received by game

processor 502, it reduces a stored coin escrow value to zero, which will cause the coin escrow display to display zero. The game processor board then sends a message to hopper processor 504 indicating a number of coins or other value indicators to be released to the player, which hopper processor 504 converts into signals sent to coin circuitry for releasing coins into hopper tray 118.

An optional network I/O processor 512 is also provided in some embodiments to allow casino operator commands to be sent over an external network as well as to allow a remote query of a status total and diagnostic data from slot machine 100.

Because of the modularity of the processors, some of the functionality of the processors and the associated mechanical devices can be located in the base which supports slot machine 100. For security purposes, enclosure 120 would be securely attached to any such base, such as base 130 shown in Figure 1. If much of the internal electronics and mechanical devices of slot machine 100 can be housed in base 130, then slot machine enclosure 120 can be made much smaller. One appeal of a smaller slot machine is that many players are comfortable with smaller slot machines, which have a more "friendly" feel to them.

Figure 6 is a wiring layout showing how various independent processor boards might be coupled.

Figure 7 is a more detailed schematic diagram of game processor board 502, showing a central processing unit (CPU) 702, a read-only memory (ROM) 704, an erasable programmable ROM (EPROM) 706, a random access memory (RAM) 708, a random number generator 710 and a clock 712. As shown, CPU 702 communicates with the RS485 bus, accepts external commands and provides data to an external monitor, as well as being connected to ROM 704, EPROM 706, RAM 708, random number generator 710 and clock 712. Clock 712 is also optionally coupled to random number generator 710 for those embodiments where the random number generated depends on a time component. CPU 702 is also shown with a coin escrow count display output for providing a display of the number of coins in escrow,

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which are displayed on coin escrow count display 128 (see Figure 1).

ROM 704 is used to store the operating program which CPU 702 executes to perform the various functions described herein. ROM 704 also stores predefined payout tables, a default display table, and other constants as necessary as explained herein.

EPROM 706 stores alternate predefined payout tables, an alternate display table, as well as default values for a return and a hit frequency.

Figure 8 shows one example of a process game processor 502 might use to control a game. The flow chart of Figure 8 is shown with a starting block 802 and flow continuing through blocks 804, 806, 808, 810, 812, 814, 816, 818, 820, 822 and 824. The process flows from one block to the next higher numbered block unless indicated otherwise.

At block 804, game processor 502 waits for a game initiation signal. A game initiation signal is either a message from door I/O processor indicating that play button 106 has been pressed or a message from handle processor 508 indicating that microswitch 222 has been tripped. Of course, a number of other will known methods of initiating a game could be used.

At block 806, game processor 502 determines whether a wager has been made. A wager could be assumed from a non-zero coin escrow count or a wager might be indicated by a message from value acceptor processor 512 indicating that a valid coin or other indicator of value has been inserted into slot machine 100. If a wager has not been made, game processor 502 loops back to block 806 until a wager has been made, at which point game processor 502 proceeds to block 808

At block 808, game processor 502 calculates a current payout table, if not already calculated, and stores i in either RAM 708 or EPROM 706. As should be apparent to one skilled in the art, RAM 708 could maintain a pointer to one o multiple payout tables. Tables 1(a)-(c) below describe some exemplary payout tables.

A payout table defines a number of payouts, each labelled with a label such as "Win A", "Win B", "Loss", etc. For each possible payout, the payout table defines the probability of occurrence of that payout, and a payout amount. Although each table below includes a column for expectation value, this need not be stored, since it can be calculated from the payout amount and the probability, and in any case, the expectation value, as such, is not used by game processor 502.

A payout table also inherently defines a hit frequency and a return, which are highlighted in Tables 1(a)-(c). The highlighted cell of the probability column, the probability of a losing game, is of course, one minus the hit frequency, and the return is the total for the expectation value column. The numbers in each of these tables are shown to four decimal places, although in practice the numbers have a resolution of 32 bits, which is enough to express numbers between 0.0 and 1.0 to about 9 decimal places.

The first table, Table 1(a), is a payout table for an intermediate payout distribution, in which intermediate payouts, such as "Win C" have a high probability. This game is preferred by customers who would rather win more often than win a big jackpot rarely.

Label	Payout	Probability	Expectation Value
Win A	1000	0.0001	0.1000
Win B	100	0.0009	0.0900
Win C	10	0.0440	0.4400
Win D	2	0.1550	0.3100
Loss	0	0.8000	0.0000
Totals		1.0000	0.9400

TABLE 1(a). Intermediate Distribution Payout Table

Note that, unlike the prior art, there is no constraint that the probabilities be multiples of some distribution function of the symbols on the reels, such as 1/8000 (0.000125) in the case of a three twenty-position reel

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slot machine where the payout probability distribution is determined by the symbols on the reels and payout rules. Table 1(a) only contains numbers which are whole multiples of 0.0001, but this is not a constraint of the invention, but was done to keep the table uncluttered. As should be apparent, the probabilities could be settable in an actual gaming machine according to the present invention with a resolution of 32 bits, i.e., constrained only to be multiples of 2^{-32}. Some embodiments may have more or less resolution.

As should also be apparent, a payout table need not be fixed. Game processor 502 could read a fixed payout table from ROM 704, or could read a return and hit frequency from ROM 704, EPROM 706 or RAM 708 (although the latter is unlikely) and calculate a payout table. The calculated payout table is then stored in EPROM 706 or RAM 708 until the game processor 502 is instructed to recalculate the payout table.

Table 1(b) is a payout table for a jackpot distribution. Using this payout table, payouts such as "Win A", a "jackpot" win are more likely. To keep the total return and hit frequency the same, the intermediate payouts are made less likely. Note that the probability of the payout with the smallest nonzero (i.e., winning) payout amount is greater than in the intermediate distribution payout table. This is to keep the hit frequency constant.

Label	Payout	Probability	Expectation Value
Win A	1000	0.0005	0.5000
Win B	100	0.0001	0.0100
Win C	10	0.0039	0.0390
Win D	2	0.1955	0.3910
Loss	0	0.8000	0.0000
Totals		1.0000	0.9400

TABLE 1(b). Jackpot Distribution Payout Table

Another type of payout table is one with a payout distribution such that each payout has an equal payout amount expectation value. This payout table is favored by some

players and casino operators because the probability of each payout is inversely proportional to the payout amount. Table 1(c) shows how such a payout table can be calculated using just the payout rules (which define the payout amounts for each payout), the hit frequency and the return. The variable E is a placeholder for the calculation.

Label	Payout	Probability	Expectation Value
Win A	1000	E/1000	E
Win B	100	E/100	E
Win C	10	E/10	E
Win D	2	(R-3E)/2	R-3E
Loss	0	1 - HF	0.0000
Totals		1.0000	R

TABLE 1(c). Even Expectation Value Payout Table

As should be apparent from Table 1(c), the payout table can be calculated from the return R, the hit frequency HF, and the payout rules (which specify payout amounts of 1000, 100, 10 and 2). For some payout rules, there is no solution which allows all the expectation values to be equal. Although there are payout rules for which this is possible, it is more sensible to allow one of the winning payouts to have what is, in a sense, a remainder expectation value, R-3E. Even if one of the payouts has a different expectation value, it is nonetheless still considered an even payout table. If one payout expectation value (in this example, the last winning payout) is not constrained to be equal to the others, then a solution can always be found. In the above example, E is found from the equation E/1000 + E/100 + E/10 + (R-3E)/2 = HF, which simplifies to E = ((500 x R) - (1000 x HF))/1389. With R = 0.94 and HF = 0.20, E is 270/1389, or approximately 0.1944.

In fact, a payout table can be calculated for any desired relative probabilities for three of the payouts shown above (or in general, for n-1 payouts where the payout rules specify n winning payouts). Significantly, any of the above

tables can be used with any given slot machine, without the need to modify the reels or the symbols on the reels, so long as the payout rules do not specify a payout for a symbol combination which is not possible with the reels used. In other words, the reels must include at least one display consistent with each payout if the probability of that payout is greater than zero.

Once a payout table is generated, game processor 502 proceeds to block 810 and generates a game random number (GRN) used to randomly select one of the payouts. GRN is generated by random number generator 710 by any one of the well known methods for generating a random number from a uniform, normalized distribution. In some embodiments, a time signal from clock 712 is used as part of a seed so that a player who studies a slot machine's behavior and knows how it calculates random numbers will not be able to determine the next random number from a discovered sequence.

At block 812, the GRN is used to select one of the payouts in any manner well known to one skilled in the art for randomly selecting one member of a plurality of members in a set where a probability is associated with each member. One method is to map each payout to a range of possible values of GRN with each range proportional to the probability for that payout. For example, in the above payout tables the losing payout has a probability of 0.8. If GRN is a random variable selected from a uniform distribution from 0.0 and 1.0, then a GRN between 0.0 and 0.8 could be designated as a selection of the losing payout.

At block 814, the payout amount for the selected payout is determined from the current payout table. In alternate embodiments, the payout amount is not determined until after block 820, as the payout amount is not needed until a payout amount message is to be sent to the top box processor to present an audio-visual display corresponding to the amount won and to the hopper processor to pay out the amount won.

Once a payout is selected, a final display consistent with that payout needs to be selected. Of course,

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slot machine 100 needs only to display one consistent final display for each payout, but to keep the game interesting, slot machine 100 randomly selects a final display from the set of possible consistent displays. This selection is done using a look up table which indicates which final displays are consistent with which payouts. An example is shown by Table 2.

Payout	Display #	Reel 1	Reel 2	Reel 3
Win A	1	BAR	BAR	BAR
Win B	1	BAR	BAR	CHERRY1
	2	BAR	BAR	CHERRY2
	...	...	...	...
	19	BAR	BAR	X16
	20	BAR	CHERRY1	BAR
	...	...	...	...
	56	X15	BAR	BAR
	57	X16	BAR	BAR
Win C	1	BAR	CHERRY1	CHERRY1
	2	BAR	CHERRY1	CHERRY2
	3	BAR	CHERRY1	CHERRY3
	4	BAR	CHERRY1	X1
	...	...	...	...
	1142	X16	X16	BAR
Win D	1	CHERRY1	CHERRY1	X1
	2	CHERRY1	CHERRY1	X2
	...	...	...	...
	324	X16	CHERRY3	CHERRY3
Lose	1	CHERRY1	X1	X1
	...	...	...	...
	6476	X16	X16	X16

TABLE 2. Possible Displays

Table 2 lists all 8000 possible displays for a three reel, twenty position slot machine. While some of the entries might appear to be the same final display because of symbols being repeated on the reels, the display is different if the player can see the edges of adjacent symbols and the adjacent symbols are different. For a gaming machine in which the final display is a poker hand, the number of final displays is 52 x 51 x 50 x 49 x 48, or 311,875,200. With that number of combinations, the final display selection might not be table-based, but instead could be rule-based. Of course, even with 8000 displays, a rule-based display selection might also be possible.

Table 2 above is the table of final displays for a slot machine where each of three reels include one BAR symbols, three cherry symbols, and sixteen symbols which do not contribute to a winning display. In this example, the payout rules are a final display of three BAR symbols results in payout "Win A", two BAR symbols results in payout "Win B", one BAR results in payout "Win C", two CHERRY symbols result in payout "Win D", and all other symbol combinations result in payout "Lose". Of course, with the present invention, the payout does not "result" from the final displays, since the payout is selected first and a consistent display is selected, although it appears to the player that the display is determined first and then the consistent payout is determined.

The particular payout rules represented in Table 2 allow for an ambiguous payout, namely the symbol combinations of one BAR and two CHERRY symbols, which are consistent with either payout "Win C" or payout "Win D". In this case, an additional payout rule is that the player will obtain the highest payout for the display. Another way of handling this ambiguity is to simply not include those displays as possible displays, which is trivial given that the payouts are determined before the displays in the present invention. However, the latter approach is not useful with the given payout rules, since a display of three BAR symbols is consistent with the first three payouts.

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If the payout is "Win A", then there is only one display to choose from, and that is set to be the final display. If the payout is "Win B", the number of consistent displays, n_b, is 57. In a basic embodiment of the invention, each of the 57 displays are assigned a probability of 1/57 (uniform distribution).

These symbol selections highlight a benefit of the present invention, which is that the payout table is independent of the display table. In the prior art, where they are dependent and each display has an equal probability, the hit frequency for Table 2 and the payout rules of Tables 1(a)-(c) would be fixed at 1524/8000, or 19.05%, and the return would be fixed at 235%! The intermediate win payout out of ten would also be three times as likely as the low win payout out of two. The casino operator using the present invention has no such constraints.

It should be apparent that the display table is not required, but is only used to vary the different possible consistent displays. In one embodiment, albeit a less interesting embodiment, only one display is used for each payout. Once the payout is selected, that one display is the selected display. The advantage to this embodiment is that it takes less computing power, since the random number for selecting the display need not be generated and Table 2 need not be created or stored in memory.

In another variation, a table such as Table 2 (or a table in which the sequence of displays is less orderly) is used, but the display selected from the plurality of consistent displays is not randomly selected. Instead, the display is selected according to a deterministic rule. For example, game processor 502 might store pointers to the last display selected of each group of consistent displays, and select the next consistent display. One advantage to this embodiment is that an unscrupulous player watching the reels for an extended time would notice the pattern of displays and attempt to determine when the high payouts will occur. Of course, since the payout determination is totally independent

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of the display determination, no information about a payout can be found from the display.

Referring again to Figure 8, at block 816, a display random number (DRN) is randomly generated, and is used to randomly select one of the displays consistent with the payout. For example, if the payout is "Win B", then DRN would cause one of the 57 displays consistent with a "Win B" to be selected. In an alternate embodiment, DRN can be derived from a portion of GRN. For example, after selecting a payout, GRN can be normalized such that GRN is evenly distributed over the range of numbers associated with a payout are normalized to a range of 0.0 to 1.0.

Once the final display is selected, game processor 502 sends a final display message indicating the final display to reel processors 306 over bus 516, at block 818. The reel processors then determine where each reel should stop. To present a pleasing game, each of reel processors 306 slows its reel 108 down before stopping it on the final symbol, and reel processor 306(1) stops reel 108(1) before reel processor 306(2) stops reel 108(2), and reel processor 306(2) stops reel 108(2) before reel processor 306(3) stops reel 108(3). In order to coordinate this, the reel processors send messages to each other over bus 516.

At block 820, game processor 502 waits for all the reel processors to send messages indicating that they have stopped their reels, and then at block 822, game processor 502 sends a payout message to top box processor 510, and at block 824 sends the payout message to hopper processor 504. The payout is known before the reels stop, but to create the impression in the player's mind that the display is not selected to conform to an already determined payout, the top box and the hopper do not react until after the final display is presented.

The top box processor causes lights 124 to flash and speaker 126 to emit sounds associated with the payout. Typically, the speaker is silent for a loss and is progressively louder for larger payout amounts, and the amoun

of visual stimulus provided by lights 124 is similarly related to the payout amount.

The hopper processor uses the payout amount message to determine how many coins or indications of value to provide to the player. If a gaming machine is so configured, no value is provided at that time to the player, but an escrow account balance is increased. Typically, the balance of the escrow account is paid out through the hopper when "CASH OUT" button 112 is pressed.

Following block 824, game processor 502 resets for the next game, and the process flows back to block 804. In the process just described, the payout and the final display are not determined until a game has started and a wager is made. In an alternate embodiment, the outcome of a next game is determined before that game begins, however this is not the preferred order, since it might allow a player with access to the internals of a slot machine to determine if the machine is set to win before the player makes a wager.

Figure 9 is a flowchart 900 which is an alternate description of a process for operating a slot machine. The process begins when a player makes a wager and initiates a game (step 902) by either pressing a start button or by pulling a handle. Once a game starts, and preferably after the reels begin spinning to limit opportunities for fraud, the game processor generates a first random number, RN1 (step 904).

The generation of RN1 is performed according to well known methods for generating random numbers. In a specific embodiment, RN1 is a 32-bit number randomly selected from all possible 32-bit numbers with each 32-bit number being equally likely. To fall between the range from zero to one, the 32-bit value is simply treated as the binary fractional portion of a number.

Once RN1 is generated, it is checked against HF, the hit frequency value for the game (step 906). In the specific embodiment HF is a 32-bit value between zero and one, and HF is settable by the owner of the gaming machine implementing this process. In one specific machine, the hit frequency is a

32-bit approximation of 0.20. If RN1 is less than HF, indicating that the game is a winning game, the process continues at step 910, otherwise, the game is a losing game and the process continues at step 908.

If the game is a winning game, a second random number, RN2, is generated (910), and is used to select a payout from a payout distribution (912). Using a random number to select one member of a set based on a probability distribution of the members is well known in the art, as explained above. In a specific embodiment, the probability distribution of payouts is described by an ordered array of payout records, wherein each record has two fields, an identifying field identifying the payout and a sum field which holds the sum of the payout's probability and the sum of probabilities of all other payouts which are prior to the payout in the ordered array. This way, the game processor need only scan through the ordered array once to select the first payout whose sum field is greater than RN2. The effect of this operation is to select a payout based on the payout probability distribution, with the selected payout determined by RN2.

The probability distribution of the payouts determines the return percentage for the game, as explained above. Significantly, the probability distribution of the payouts is not constrained at all by the distribution of symbols on the reels, or in any other way determined by the final display, since the final display is determined after the payout is selected.

If the game is a losing game, as determined in step 906, the process continues with step 908, where the one losing payout (typically having a payout amount of zero, or some small consolation prize which may or may not be money) is selected.

Whether the game is a winning game or a losing game, a third random number, RN3, is generated (step 914), and the game processor uses RN3 to select one display from a set of consistent displays (916). The probability distribution of displays within a set of consistent displays can either be a

uniform distribution (each display equally likely) or a non-uniform distribution (some displays are favored, such as "near-miss" displays). The determination of which displays are consistent with which payouts is a straightforward exercise as described above.

Once a final display is selected, the game processor causes the reel processors to control the reels so that the reels stop in a position which displays the selected display (918). If a winning game was hit (as determined in step 906), decision step 920 directs the process to step 922, otherwise the game ends. At step 922, the player is credited with the payout amount associated with the selected payout, and then the game ends. In some embodiments, when the game is a losing game and the payout is not zero, the player is provided with the consolation prize.

In summary, this description describes gaming machines, slot machines in particular, where a payout is selected according to a payout distribution independent of the distribution of symbols used for the possible displays, and a final display is selected from a set of displays consistent with the selected payout. The gaming machine is arranged so that it appears to a player that the display is determined before the payout, and in the case of slot machines, that the stopping positions of the reels are determined by the random effects of friction, as was the case with older, purely mechanical slot machines.

Furthermore, a slot machine is described where an electronic linkage is provided between the handle and the reels to simulate the mechanical linkage of older machines. A reel decoding apparatus and method are also described which allows a reel processor to determine a reel position independently of a count of steps of a stepper motor without needing to rotate the reels to a zero position indicator. A distributed processing system for controlling various aspects of the slot machine, with many advantages is also disclosed.

The above description is illustrative and not restrictive. Many variations of the invention will become apparent to those of skill in the art upon review of this

disclosure. Merely by way of example, the probability distribution of displays need not be a uniform distribution over all consistent displays, but need only be zero for each inconsistent display, such as a distribution which favors (makes more probable) losing displays which are adjacent to winning symbols, to create "near-miss" displays. The scope of the invention should, therefore, be determined not with reference to the above description, but instead should be determined with reference to the appended claims along with their full scope of equivalents.

Appendix A is a source code listing of a program used to control a programmed computer according to the present invention. The program is written in the C programming language, and can be compiled with a C compiler as is well known in the art. In a particular embodiment, the complied code is stored in ROM 704 and is executed by CPU 702 to perform steps shown in the flowchart of Figure 8.

Source Code Appendix A

```
/*  Copyright 1994 Spintek International, Inc.

     The game algorithm of this machine is based on the
equation:

   HF*(p1*pay1 + p2*pay2 +...+ pN*payN) = PC*CP

   where CP is Coins Played
         PC is desired game return percentage
         HF is desired game hit frequency

     pN is the probability of winning payN, which we have
selected to be the lowest payout amount, LP.  pN equals 1
minus the sum of the other probabilities since the sum of the
probabilities must equal 1.  In equation form, this is:

   pN = 1 - (p1 + p2 +...+ pN-1)

and it follows that

   pN*payN = 1*payN - (p1*payN + p2*payN +...+ pN-1*payN)

and

   HF*[(p1*(pay1-payN))+(p2*(pay2-payN))+...+1*payN] = PC*CP.

The win percentages (i.e., values for p1, p2, ..., pN-1) for
an even expectation value payout table are calculated by
finding the value of the sum of:

   (p1*(pay1-payN)) + (p2*(pay2-payN)) +...

and dividing that sum equally amongst the payouts thus giving
each payout approximately equal expectation.  The first win
percentage is then:

   p1=[(((CP*PC)/HF)-LP)/(NP-1)]/(pay1-payN)

and the others are similarly calculated.  The subroutine
load_win_percentage() is called on power up, upon entry of a
new game return percentage value or hit frequency value.

load_win_percentage() calculates the values to be entered into
the payout table, which is the array win_percentage[][] here.
An intermediate double float value, d, is calculated first to
limit multiple recalculation of common factors.  The equation
for d is:

   d=(((CP*PC)/HF)-LP)/(NP-1)

   where CP is Coins Played
         PC is desired game return percentage
         HF is desired game hit frequency
         LP is the lowest nonzero payout amount and
         NP is the number of nonzero payouts (including LP).
```

```
The variable d is converted to a 32 bit fraction, w, and win
percentages are calculated as (w/(pay-LP)) + the sum of the
previously calculated win percentages to allow a simple table
search.  The last table value (associated with the lowest pay,
LP) is arbitrarily set equal to 0xFFFFFFFF, which is the
maximum value of a random number in this system.
*/

void load_win_percentage (void)
{
double d;
unsigned long w;
unsigned long sum;
int i;
int j;

   for (i=0; i<max_coins; i++){

      sum=0;

      d = ((double) (((unsigned long) (i+1)) * desired_pc));
      d /= ((double) hit_frequency_pc);
      d -= ((double) payout_amt[i][number_of_payouts-1]);
      d /= ((double) (number_of_payouts-1));

      w = (unsigned long) (0xFFFFFFFF*d);

      for (j=0; j<(number_of_payouts-1); j++){

         sum += (w/((unsigned long)(payout_amt[i][j]
                  - payout_amt[i][number_of_payouts-1])));

         win_percentage[i][j]=sum;
      }

      win_percentage[i][number_of_payouts-1]=0xFFFFFFFF;
   }
}

/*
     Game play outcome is determined by a single call to the
subroutine generate_game_result().  This subroutine calls a
pseudo-random number generator subroutine which returns a 32
bit unsigned long integer in the range [0, 0xFFFFFFFF].  The
random number is compared with the unsigned long integer
hit_frequency.  If the random number is less than or equal to
hit_frequency, the game is a winner.  If the game is a winner,
a second random number is generated which is compared with the
values in the payout table (win_percentage[][]) starting with
the lowest payout amount.  When a win_percentage table value
is found that is greater than the random number, the
corresponding pay amount and symbol combination set is
selected as the game outcome.

     If the game is a loser, the payout amount is set to zero
and a losing symbol combination set is selected.
*/
```

```
void generate_game_result(void)
{
unsigned long r;
int i;
int j;
unsigned char code *combo;

   if(rng()<=hit_frequency){ /* WINNER*/

      r=rng();  /* Get second random number*/

      /* Assume lowest pay */

      pay_amount =
         payout_amt[coins_played-1][number_of_payouts-1]

      combo =
         get_pay_combination_ptr(machine_selection,
                                 number_of_payouts-1);

/* Compare random number with win percentages */

      for (i=0; i<number_of_payouts-1; i++){

         if(r<=win_percentage[coins_played-1][i]){
            pay_amount =
                payout_amt[coins_played-1][i];
            combo =
                get_pay_combination_ptr(machine_selection,i);
            break;
            }
         }
      }

   else{  /* LOSER /*
/* Use zero pay amount and a consistent symbol combination. */

      pay_amount=0;
      combo=get_pay_combination_ptr(machine_selection,
                                    number_of_payouts);
      }

   for (j=0; j<number_of_reels; j++) {
      display_combination[j] = (*combo);
      display_position[j] =
            get_reel_strip_position(machine_selection,
                                    display_combination[j]);
      combo++;
      }

/* Do accounting functions */

   coin_in_meter+=coins_played;
   coin_out_meter+=pay_amount;
   actual_percentage=(100*coin_out_meter)/coin_in_meter;
}
```

WHAT IS CLAIMED IS:

1. A gaming machine comprising:

a value acceptor for accepting indications of value from a player;

game initiating means, coupled to said value acceptor, for initiating a game when said indication of value has been accepted;

game processing means, coupled to said game initiating means, for determining an outcome of said game, said outcome defining at least a payout;

game display means, coupled to said game processing means, for displaying, over a nonzero time, a progression of said game ending with a final display consistent, according t predetermined payout rules, a payout amount of said payout;

payout means, coupled to either said game processin means or said game display means, for providing value to said player consistent with said payout amount;

a slot machine enclosure enclosing said value acceptor, said game initiating means, said game display means and said payout means; and

a plurality of processors, at least one in each of said value acceptor, said game processor, said game display means, and said slot machine enclosure, each of said pluralit of processors including an independently operating central processing unit, thereby allowing each processor to be reconfigurable and replaceable without requiring reconfiguration of other processors.

2. The gaming machine of claim 1, wherein said outcome defines said payout amount and said final display.

3. The gaming machine of claim 1, wherein said value acceptor and said payout means operate on different forms of value selected from coins, bills, tokens, scrip, or electronic credits and debits.

4. The gaming machine of claim 1, wherein said gam display means is one of a plurality of reels rotating about a

common axis or a video screen which simulates plurality of reels rotating about said common axis.

5. The gaming machine of claim 4, wherein said display means is programmed to rotate said reels of simulated reels during said nonzero time, stopping said reels or simulated reels one at a time until said final display is reached.

6. The gaming machine of claim 1, wherein the gaming machine is a slot machine.

7. The gaming machine of claim 1, wherein the game processing means determines a payout according to a payout table, said payout table selectable by a player from a plurality of possible payout tables.

8. A slot machine comprising:

a plurality of reels mounted to rotate about a common axis;

a game processor for determining final position for said plurality of reels;

a handle coupled to said game processor and positioned to allow handle movement by a player such that when said handle is moved from a resting position to a full rotation position, said game processor initiates rotation of said reels; and

a sensor coupled between said handle and said game processor for detecting travel of said handle between said resting position and said full rotation position, wherein said sensor provides said game processor with an indication of a distance of said detected travel.

9. The slot machine of claim 8, wherein said game processor is programmed to move one or more of said plurality of reels through an angular distance of less than a full rotation when said sensor provides an indication that said

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handle is moved through less than said travel between said resting and full rotation positions.

10. The slot machine of claim 8, wherein said game processor comprises a plurality of processors, including one processor per reel of said plurality of reels.

11. A slot machine comprising:

a plurality of reels mounted to rotate about a common axis;

a game processor for determining a final position for said plurality of reels;

a plurality of stepper motors, at least one per reel of said plurality of reels, each stepper motor controlled by said game processor;

wherein said game processor is programmed to slow the rotation of a reel using the stepper motor until said reel is stopped at a predetermined angular position, to simulate a frictional slowing of said reel.

12. A slot machine comprising:

a plurality of reels mounted to rotate about a common axis;

a game processor for determining final position for said plurality of reels;

a plurality of stepper motors, at least one per reel of said plurality of reels, each stepper motor controlled by said game processor;

means for indicating an alignment offset position of a reel;

memory coupled to either said game processor or a reel processor dedicated to control of one or more of said plurality of reels,

wherein said memory stores said alignment offset position and wherein said game processor or said reel processor uses said alignment offset position to control said stepper motor.

13. The slot machine of claim 12, wherein said game processor or said reel processor is programmed to stop said plurality of reels at positions offset by said alignment offset position, thereby providing each of said plurality of reels with an angular rotation necessary to keep a symbol centered in a display window.

14. The slot machine of claim 12, further comprising means coupled to said game processor for generating an electronic signal when a reel is in a zero position, said reel having one zero position with a known spatial relationship to centers of symbols on said reel.

15. A method of operating a gaming machine, wherein a game begins with a wager and the gaming machine provides a player with payout rules, the method comprising the steps of:

randomly selecting a payout from a plurality of payouts according to a probability distribution of said plurality of payouts;

then, randomly selecting a display from a set of displays which are consistent with the payout rules and said selected payout;

displaying said selected display; and

crediting the player with a payout amount of said selected payout.

16. The method of claim 15, wherein one of said plurality of payout has a payout amount of zero and is associated with a losing game.

17. The method of claim 15, further comprising the steps of:

associating sets of combinations of symbols with each of said payouts, thereby defining payout rules,

wherein each display in said set of displays comprises a combination of symbols, and wherein a given display is consistent with a given payout if and only if said

given display comprises a combination of symbols which is a member of a set associated with said given payout.

18. The method of claim 15, wherein said combinations of symbols are poker hands.

19. The method of claim 15, further comprising the step of stopping a plurality of reels in stopping positions to display said selected display, said stopping positions being such that said plurality of reels display, in a window, the combination of symbols which the selected display comprises.

20. The method of claim 15, wherein said probability distribution of displays is a uniform probability distribution over all displays consistent with said selected payout.

21. A method of operating a gaming machine, wherein a game begins with a wager and the gaming machine provides a player with payout rules, the method comprising the steps of:

randomly selecting a payout from a plurality of payouts according to a payout probability distribution of said plurality of payouts, wherein said step of randomly selecting a payout is performed without reference to a distribution of symbols on a display;

then, selecting a display from a set of displays which are consistent with the payout rules and said selected payout;

displaying said selected display; and

crediting the player with a payout amount of said selected payout.

22. The method of claim 21, wherein only one display in said set of displays is consistent with the payout rules and said selected payout, thereby reducing said step of selecting a display to a step of identifying said only one display.

23. The method of claim 21, wherein said step of selecting a display is a step of randomly selecting one display consistent with said selected payout from said set of displays when said set of displays comprises a plurality of displays consistent with said selected payout.

24. The method of claim 21, wherein said step of selecting a display is a step of selecting one display consistent with said selected payout from said set of displays when said set of displays comprises a plurality of displays consistent with said selected payout, wherein said one display is determined unambiguously from said selected payout and a predetermined rule.

25. The method of claim 21, wherein said step of randomly selecting a payout comprises the steps of:

determining said plurality of payouts;

associating each payout amount of a plurality of payout amounts with each payout of said plurality of payouts;

calculating a return percentage for said plurality of payouts as a weighted sum of said each payout amount weighted by a payout probability of said associated payout, said payout probability determined according to said payout probability distribution;

adjusting one of said payout probability distribution or said plurality of payout amounts when said return percentage is other than a desired return percentage to reduce a difference of said return percentage and said desired return percentage; and

randomly selecting said payout according to results of said step of adjusting.

26. The method of claim 25, wherein said step of calculating said return percentage comprises the steps of first calculating a hold percentage and then subtracting said hold percentage from one to result in said return percentage.

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27. The method of claim 25, wherein said step of step of calculating is performed each time a game is played.

28. The method of claim 25, wherein said step of step of calculating is performed whenever a gaming machine operator desires to adjust said hit frequency or said return percentage, the method further comprising a step of accepting a new value for said hit frequency or said return percentage from said gaming machine operator, thereby creating a payout probability distribution reflecting any adjustments to said hit frequency or said return percentage.

29. The method of claim 21, wherein said step of randomly selecting a payout comprises the steps of:

determining said plurality of payouts;

calculating a hit frequency for said plurality of payouts as a sum of probabilities of payouts which result in a nonzero payout amount, said probabilities determined according to said payout probability distribution;

adjusting said payout probability distribution when said hit frequency is other than a desired hit frequency to reduce a difference of said hit frequency and said desired hit frequency; and

randomly selecting said payout according to results of said step of adjusting.

30. The method of claim 29, wherein said step of step of calculating is performed each time a game is played.

31. The method of claim 21, wherein said plurality of payouts includes only winning payouts and the method further comprising a step of randomly selecting between a winning game and a losing game according to a hit frequency value, followed by said step of randomly selecting a payout from among said winning payouts only when said winning game i selected.

32. The method of claim 21, wherein plurality of payouts includes only winning payouts and the method further comprising a step of randomly selecting between a winning outcome and a losing outcome according to a hit frequency value, followed by said step of randomly selecting a payout from among said winning payouts.

33. The method of claim 32, wherein said hit frequency value is a value between zero and one, wherein an expectation value of a payout amount over said plurality of winning payouts multiplied by said hit frequency value is a return value between zero and one.

34. A method of operating a gaming machine, wherein a game begins with a wager and the gaming machine provides a player with payout rules, the method comprising the steps of:

generating a first random number;

selecting a game result from a hit and a non-hit according to a hit frequency and said first random number;

generating, when said game result is said hit, a second random number;

selecting, when said game result is said hit, a payout from a plurality of payouts, according to a probability distribution of said plurality of payouts and said second random number;

selecting, when said game result is said non-hit, a payout with a zero payout amount;

generating a third random number;

selecting a display from a set of displays which are consistent with the payout rules and said selected payout;

displaying said selected display; and

crediting, when said game result is said hit, the player with a payout amount of said selected payout.

35. The method of claim 34, wherein said probability distribution of said plurality of payouts is independent of a distribution of displays in said set of displays.

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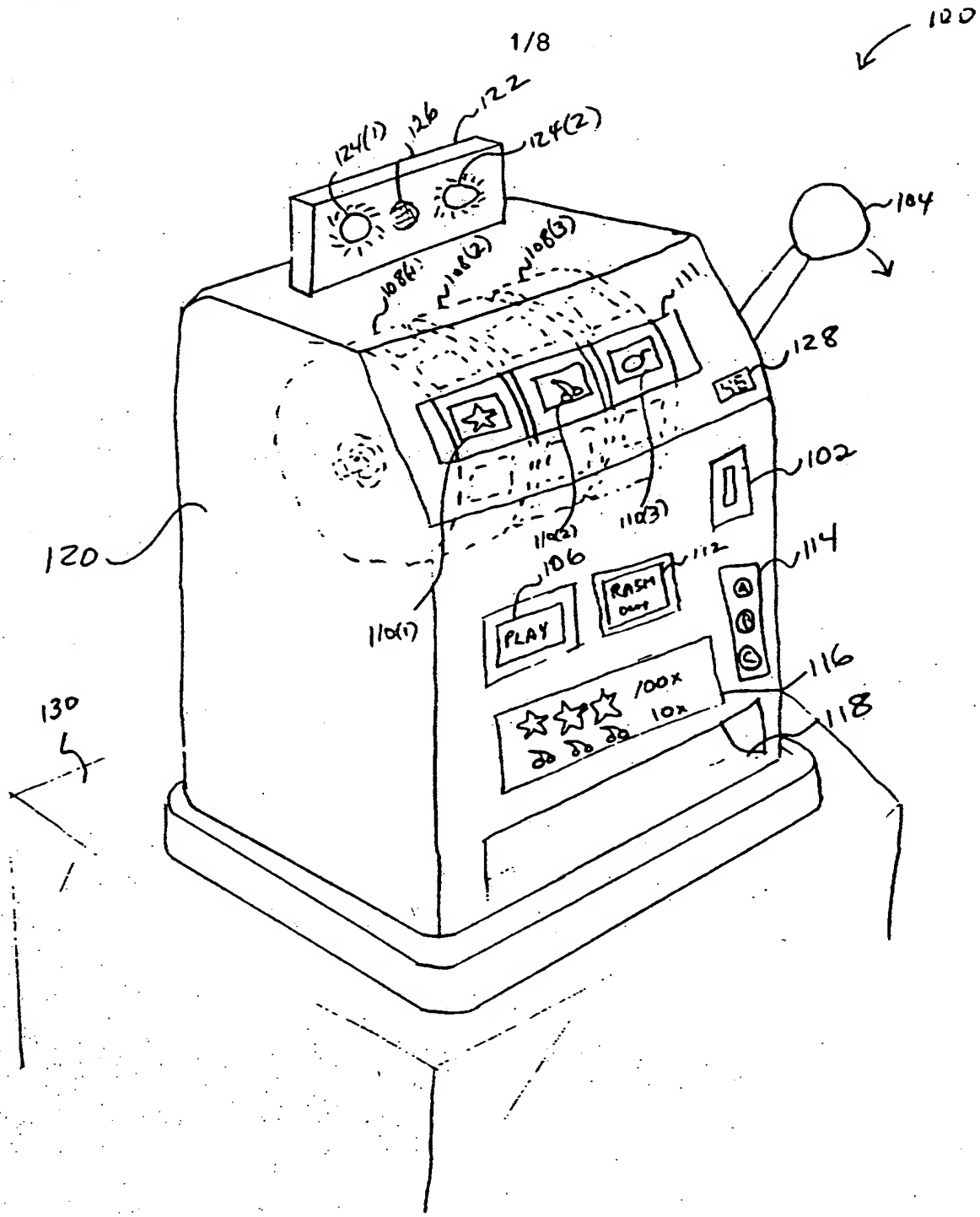
100
122
124(1)
126
124(2)
104
108(1)
108(2)
108(3)
111
128
102
120
110(2)
110(3)
106
112
114
110(1)
PLAY
CASH OUT
A
B
C
116
100x
10x
130
118

FIG. 1

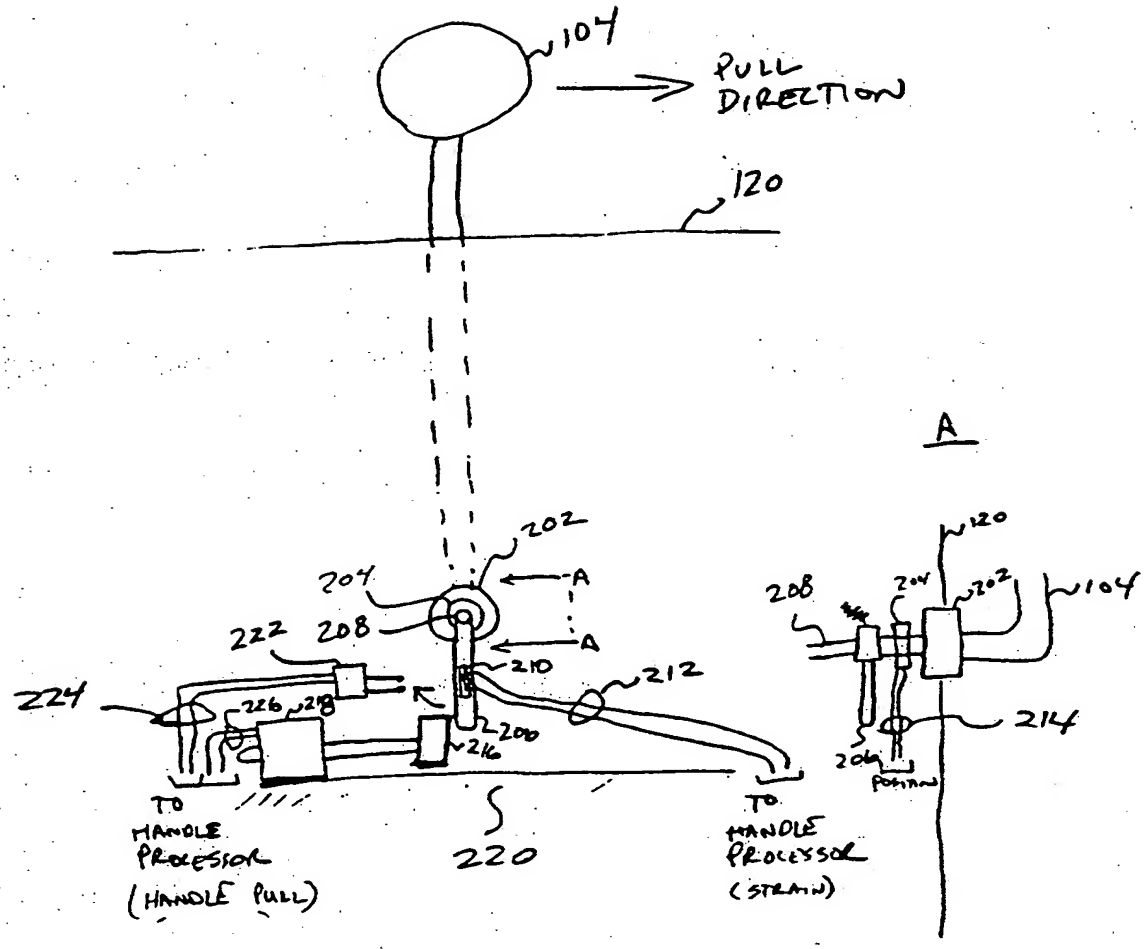

FIG. 2

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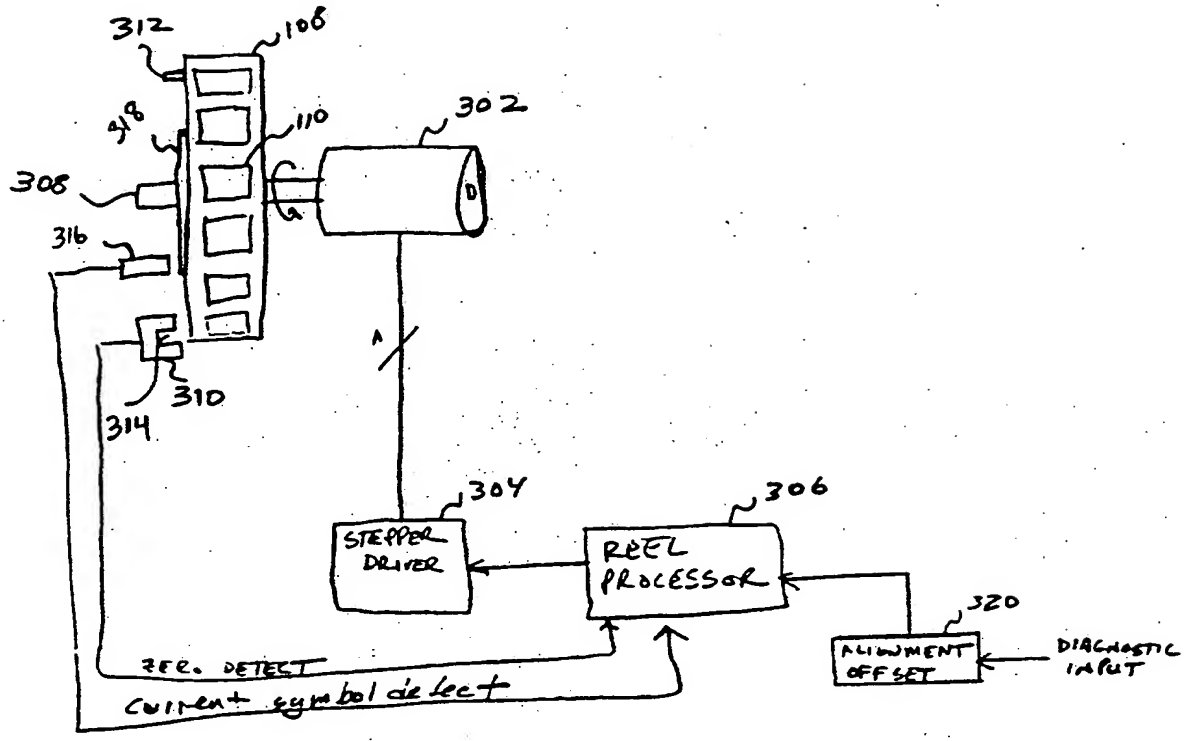
312
108
318
110
302
308
316
310
314
304
306
STEPPER DRIVER
REEL PROCESSOR
320
ALIGNMENT OFFSET
DIAGNOSTIC INPUT
REF. DETECT
current symbol detect

FIG. 3

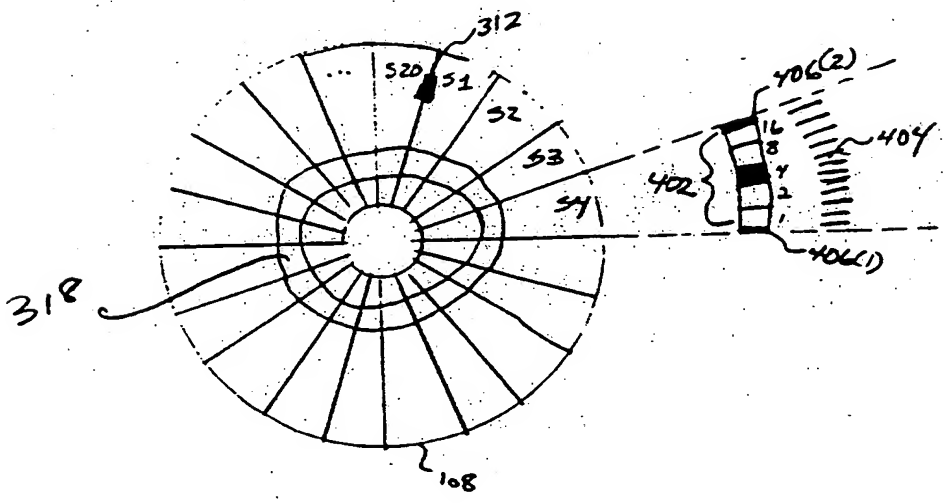
312
S20
S1
S2
S3
S4
406(2)
404
402
16
8
4
2
1
406(1)
318
108

FIG. 4

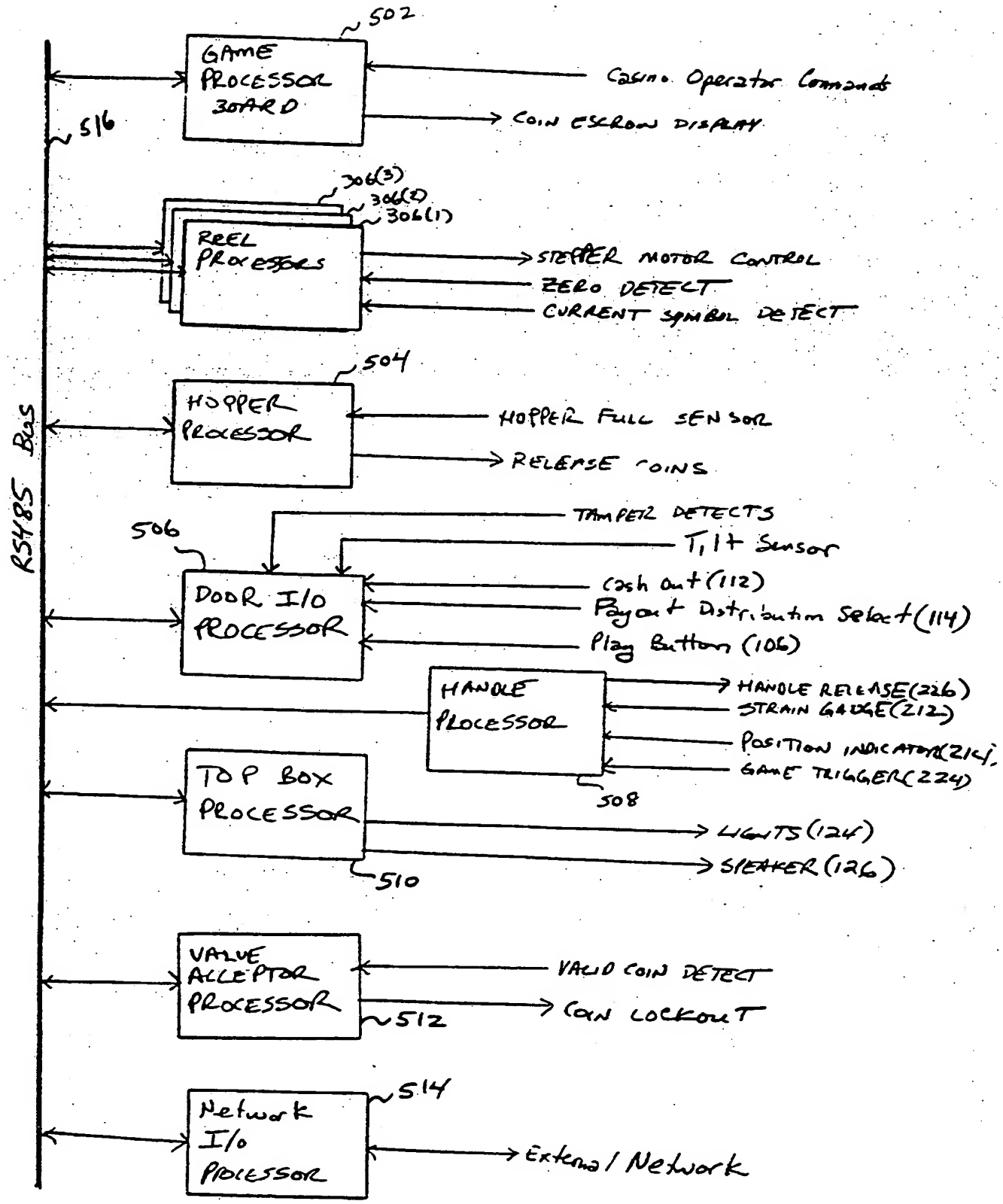

FIG. 5

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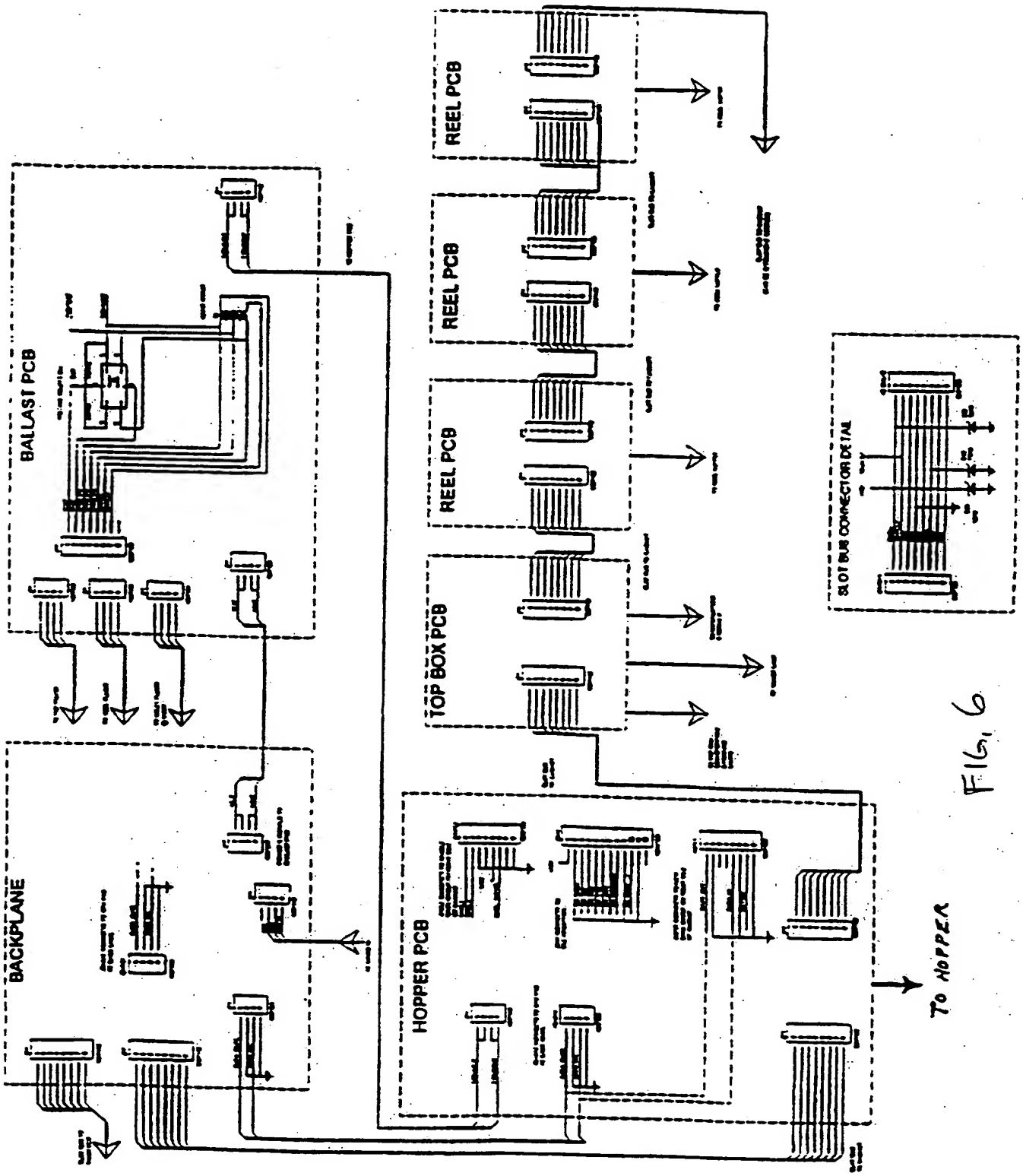

REEL PCB
REEL PCB
REEL PCB
TOP BOX PCB
SLOT BUS CONNECTOR DETAIL
BALLAST PCB
BACKPLANE
HOPPER PCB
TO HOPPER

FIG 6

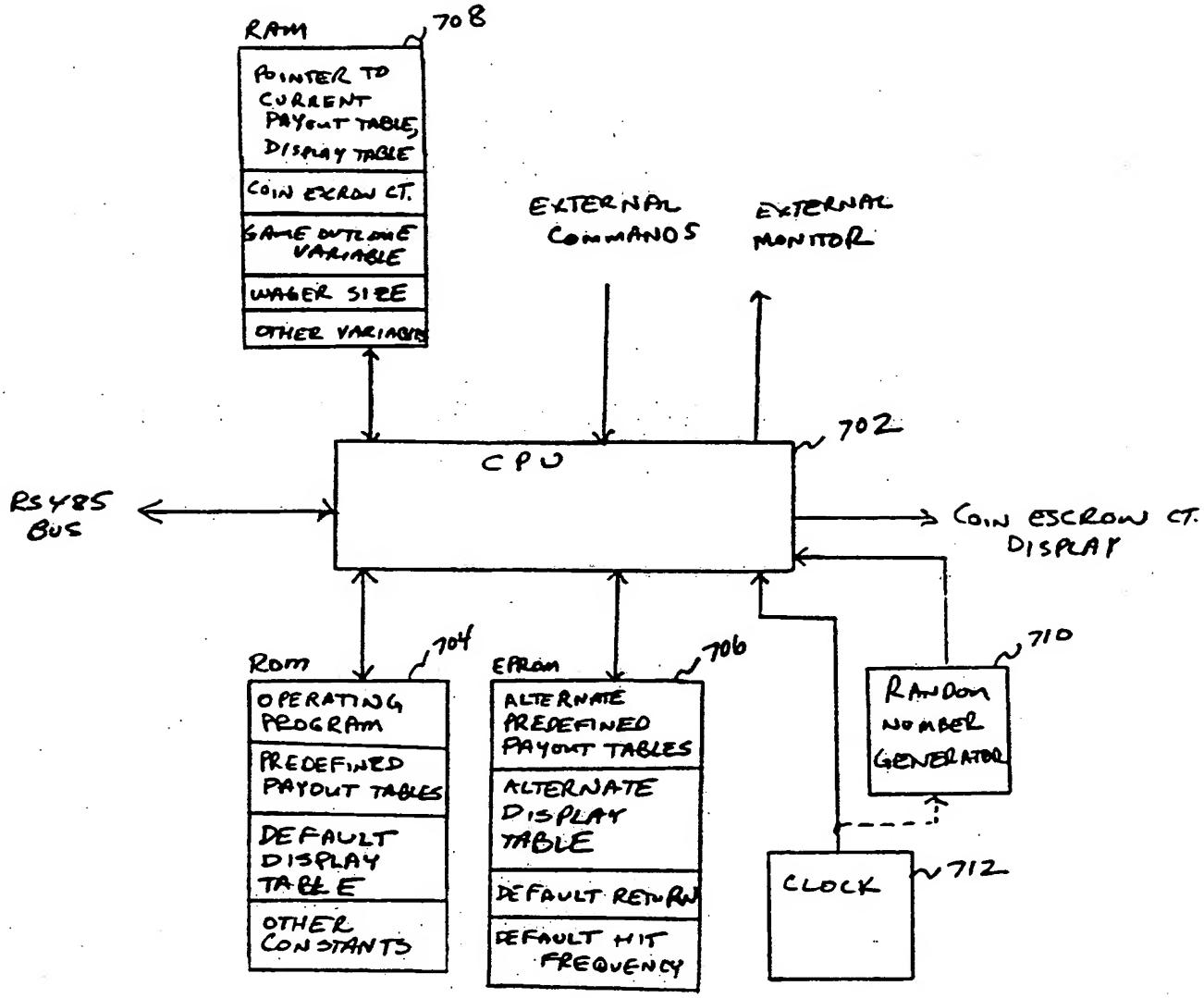
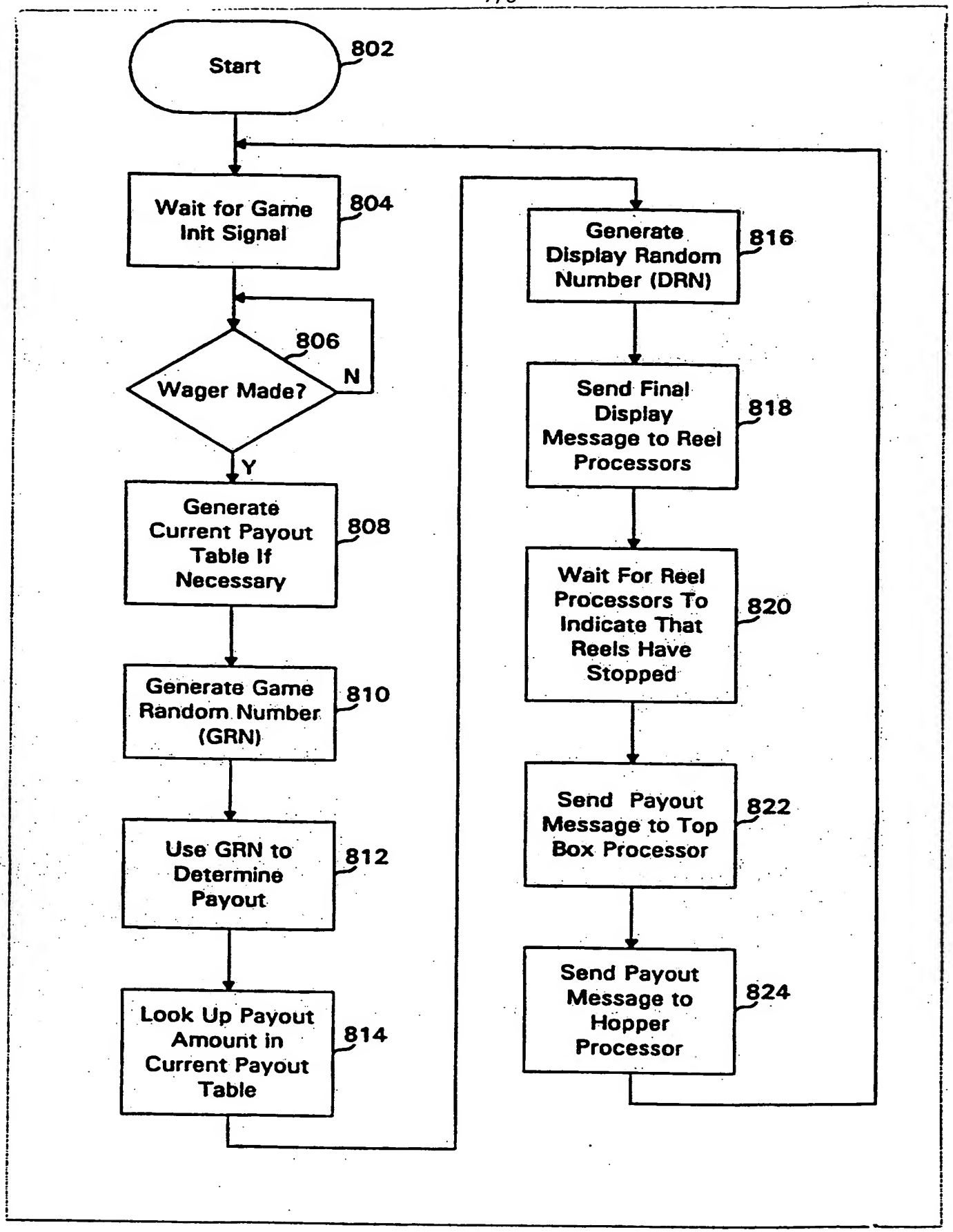

RAM
708
POINTER TO CURRENT PAYOUT TABLE, DISPLAY TABLE
COIN ESCROW CT.
GAME OUTCOME VARIABLE
WAGER SIZE
OTHER VARIABLES
EXTERNAL COMMANDS
EXTERNAL MONITOR
CPU
702
RS485 BUS
COIN ESCROW CT. DISPLAY
ROM
704
OPERATING PROGRAM
PREDEFINED PAYOUT TABLES
DEFAULT DISPLAY TABLE
OTHER CONSTANTS
EPROM
706
ALTERNATE PREDEFINED PAYOUT TABLES
ALTERNATE DISPLAY TABLE
DEFAULT RETURN
DEFAULT HIT FREQUENCY
RANDOM NUMBER GENERATOR
710
CLOCK
712

FIG. 7



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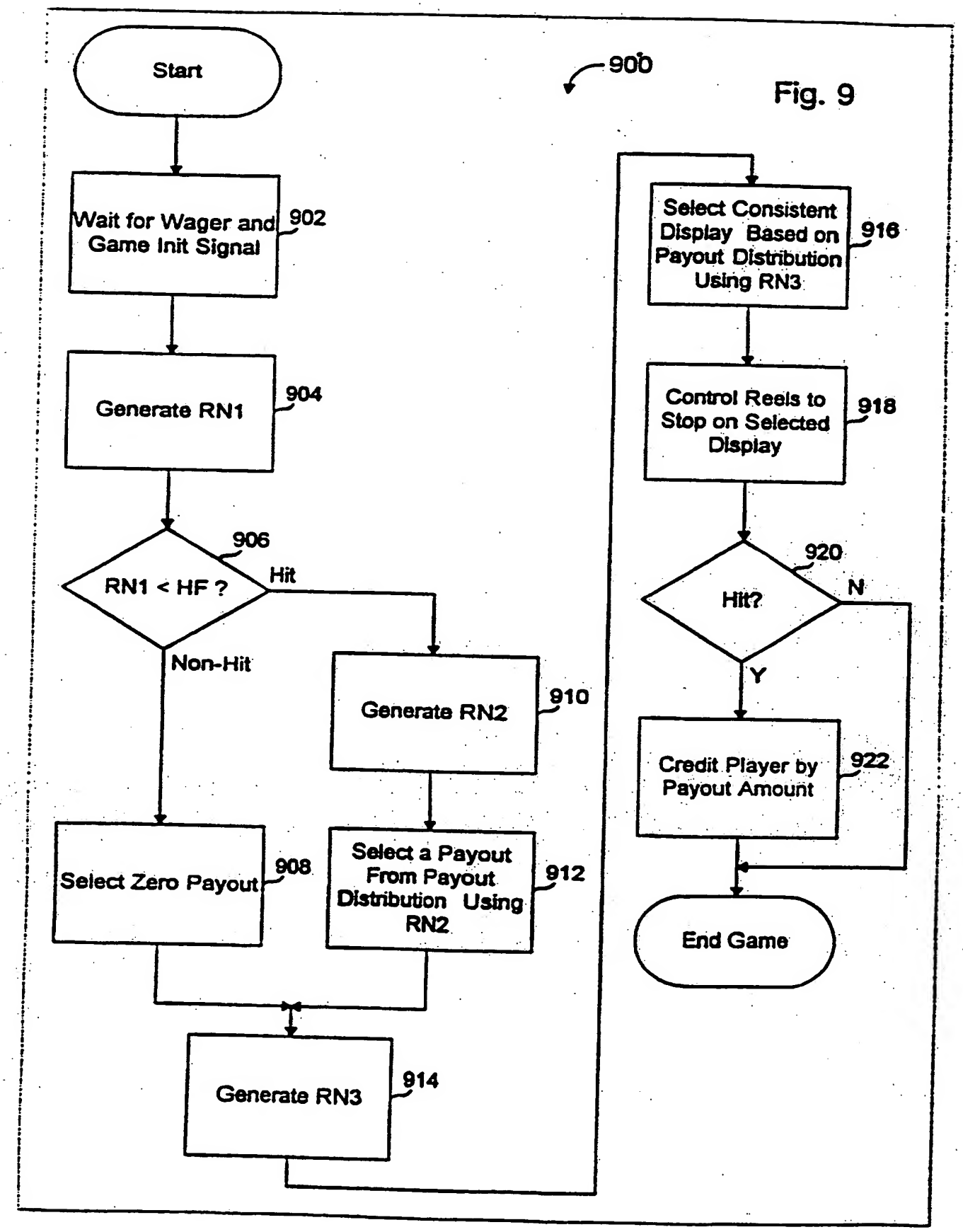

Fig. 9

BNSDOCID: <WO_____9608295A1_I_>

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/11658

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A63F 1/18
US CL :273/138A, 142R, 143R
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 273/85CP, 85G, 138A, 139, 142R, 143R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 5,074,559 (OKADA) 24 December 1991, see entire document.	21, 23, 31-32 --- 22, 24-26, 28, 29, 33-35
X --- Y	US, A, 4,772,023 (OKADA) 20 September 1988, see entire document.	15-17, 19 --- 1-10, 12-14, 18, 34, 35
Y	US, A, 5,102,136 (HEIDEL ET AL.) 07 April 1992, see entire document.	10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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08 NOVEMBER 1995

Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/11658

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,018,737 (OKADA) 28 May 1991, see entire document.	5, 11
Y	US, A, 4,889,339 (OKADA) 26 December 1989, see column 3 line 46.	3
Y	US, A, 4,817,951 (CROUCH ET AL.) 04 April 1989, see entire document.	24
Y	US, A, 4,790,537 (SMYTH ET AL.) 13 December 1988, see entire document.	12-14
Y	GB, A, 2 200 779 (JPM LIMITED) 10 August 1988, see entire document.	14
Y	EP, A, 0 099 189 (BALLY MANUFACTURING CORPORATION) 25 January 1984, see entire document.	1-7
Y	GB, A, 2 103 856 (JPM LIMITED) 23 February 1983, see entire document.	8-10
Y	US, A, 3,733,076 (OHKI) 15 May 1973, see Figs. 1, 2 and 5.	18

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CORRECTED VERSION*

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A63F 1/18

A1

(11) International Publication Number: WO 96/08295

(43) International Publication Date: 21 March 1996 (21.03.96)

(21) International Application Number: PCT/US95/11658

(22) International Filing Date: 15 September 1995 (15.09.95)

(30) Priority Data:
08/307,282 16 September 1994 (16.09.94) US

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(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).

Published

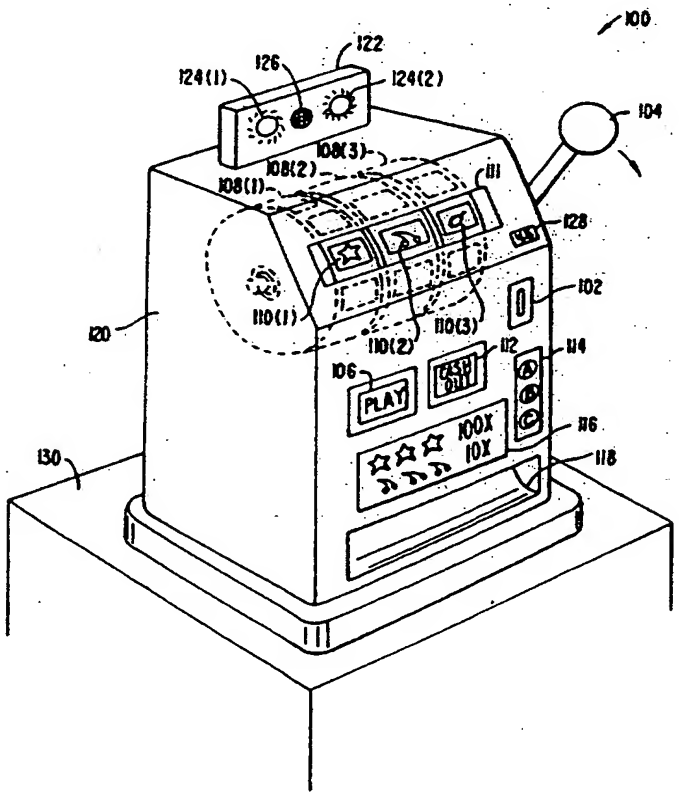
With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: ELECTRONICALLY-CONTROLLED GAMING MACHINE WITH INDEPENDENT OUTCOME SELECTION

(57) Abstract

A gaming machine (100) is provided with various modules which together form a distributed processor control system for the gaming machine. Each module communicates synchronously with other modules over a bus (5, 16). When used with a mechanical reel slot machine, a pull handle (104) activates a game, and the reels are controlled by stepper motors (302) to create the appearance of a mechanical linkage. During the play of the game, the stepper motors (302) rotate the reels and cause them to slow down and stop at the symbol combination of the selected outcome, to simulate the frictional slowing of reels in a mechanical slot machine where the stopping position of the reels is determined by frictional forces. A game processor (502) determines the outcome. The probability of a given payout is independent of the distribution of symbols on the reels, so a player can be provided a choice of different payout tables. In one embodiment, the game processor (502) may generate a random number to determine if a hit has been made (906). If a hit was made, a second random number may be generated to select a payout from a payout distribution (912). A third random number may be generated to select a consistent display based on the payout distribution (916).



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ELECTRONICALLY-CONTROLLED GAMING MACHINE WITH INDEPENDENT OUTCOME SELECTION

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CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of Application Serial No. 08/162,501 filed December 3, 1993, which is incorporated herein by reference for all purposes.

BACKGROUND OF THE INVENTION

This invention relates to gaming machines and more particularly to slot machines, which are gaming machines wherein a game outcome is indicated by the symbols on a set of reels appearing in a window, either using mechanical reels or electronically simulated reels.

The operation of gaming machines vary, but have several common characteristics, such as that a player makes a wager, and either the wager or the player initiates a game. When the game ends, the gaming machine displays a final result and provides a payout amount. For losing games, the payout amount is usually zero. A payout defines a payout amount or payout-to-wager ratio and a probability of occurrence. The resulting display and payout are collectively referred to herein as the game outcome.

The casino business is very dynamic. Typically, a casino operates many gaming machines and offers many different varieties of machine on its gaming floor. A modern casino is usually set up to determine on a weekly, daily, or even hourly basis, which machines are being played more often than others, using automated monitors or well-placed observers. Because the revenues of a casino are determined by how many players are using their machines, and how much they are playing, a casino would like all players in the casino to be able to play a machine of their choice. Consequently, a casino would rather replace an unpopular machine with a popular one than have players constantly waiting to play a popular machine.

Therefore, to have as many simultaneous players using the available machines, a casino must be able to easily change the distribution of machines on its floor. However, this capability has been quite costly for casino operators, since it requires the casino operator to maintain a large number of unused machines in reserve to swap in when they become more popular than the machines currently on the gaming floor. One example is video slot machines and mechanical reel slot machines. If the video slot machines are relatively unpopular compared to mechanical slot machines, the adept casino operator will adjust the proportion of machines on the gaming floor to ensure that more mechanical slot machines are available for play than video slot machines.

Other factors which affect the popularity of the games relate to its payout characteristics, in particular, the hit frequency, the hold percentage and the payouts.

Hit frequency is the frequency with which a game results in a winning game. This is a probability, so it is usually expressed as a percentage or as a fraction or decimal number between 0 and 1. By adjusting the hit frequency, the casino operator can modify the appeal of a game. For example, with a hit frequency of 5%, a player is likely to lose nineteen out of twenty games, and this can be quite discouraging. However, with a high hit frequency, such as 40%, a player will win more often. Of course, the amount a casino will pay out for each win is less if the wins occur

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more frequently, since a casino expects not to pay out more than it takes in. The hit frequency is equal to one minus the probability of a losing game.

The hold percentage is the percentage of the money wagered which the casino operator expects to keep (or pay out if this number is, for whatever reason, negative). One minus the hold percentage of a particular game is the game's return, i.e., what ratio of the amount wagered is returned to the player on average. For example, a machine with a hold percentage of 6% can be expected in the long run to pay out 94% of what it takes in, leaving 6% for the casino operator. Thus, on average, a player playing 100 games, wagering one coin per game, can expect to receive 94 coins. Of course, in the short run, some players will win more than wagered and some players will win less than 94% of the amount wagered. The return affects the popularity of a game, and often casinos will advertise their return percentage as a way to get customers into their casinos.

The hit frequency, return and payouts are referred to herein collectively as the payout table, which is a table of the possible payout amounts and their probabilities. The payout table includes a losing game as a payout having a payout amount of zero and a probability of occurring equal to one minus the hit frequency. In a payout table, the sum of the probabilities of all the payouts is one and the sum of the amounts of each payout weighted by its probability is the return.

In a typical machine, the player wins coins, tokens, or other indicators of value, equal to the payout amount times the wager, and the payout amount and wager need not be the same type of value indicator.

With all other things being equal, a machine with a higher return will be more popular, and a machine with a higher hit frequency will be more popular. However, an interest in increasing a machine's popularity must be balanced against the need for a casino to turn a profit on the gaming machines. In order to respond quickly to differing customer desires, a casino operator needs to be able to adjust the

payout characteristics for each of its machines, as well as to adjust the distribution of machine types placed on the gaming floor.

Historically, slot machines were mechanical reel machines. In a mechanical reel machine, a number of reels are provided each having a number of stopping positions, with a symbol displayed in a symbol window for each stopping position. The symbol window allows the player to see the symbols associated with the stopping positions, and also allows the player to see the other symbols on the reels as the reels are spinning before they stop at their stopping positions. A typical machine has three reels, with twenty stopping positions on each reel, each stopping position being equally likely. The symbols at the stopping positions might be easily recognizable fruits, such as cherries and plums, or shapes, such as stars and bells, or abstract symbols such as "7", "JACKPOT", or "BAR". The symbols need not be equally likely, even if the stopping positions are equally likely, since several stopping positions can have the same symbol associated with it. If symbols are repeated on a reel, then the number of different final displays will of course be less than the number of different stopping position combinations.

In prior art mechanical reel machines, the game outcome is determined by the stopping positions of the reels. The final display is the combination of symbols shown in the symbol window when the reels have stopped, and the payout amount is determined according to payout rules. The payout rules for a game might dictate that a player wins 2 times the wager if the final display is two cherry symbols appearing in the window and wins a thousand times the wager if the final display is three star symbols. Since the distribution of symbols on the reels is known, and each stopping position is equally probable, the probability of each payout is easily calculated.

Using basic probability theory, a casino operator can determine the hit frequency and return for a machine from the distribution of symbols and the payout rules. In fact, given the payout rules, the distribution of symbols determines

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the entire payout table. For the three reel, twenty position machine described above, there are 8000 (20 * 20 * 20) different stopping position combinations, all equally likely (barring illegal manipulation of the machine or malfunction). Suppose for the simplicity of the example, that each reel is provided with a single star symbol, five cherry symbols and fourteen symbols which do not contribute to any winning combination. Further suppose that the payout rules are as follows: a player wins 2000 times the wager for three stars and 10 times the wager for three cherry symbols. Since the distribution of symbols on the reels and the payout rules determine the payout table, the hit frequency and the return for this game are determined by the machine. The probability of getting three stars is one in 8000 (or .0125%) and the probability of getting three cherry symbols is one in sixty four (125/8000, or 1.5625%), so the hit frequency is about one out of sixty three games ([125+1]/8000, or 1.575%) and the return is about 40% ([[125*10]+[1*2000]]/8000). With this hit frequency and return, the machine is not likely to be popular, so different reels or different symbols sets should be used, or the payout rules should be changed.

In some cases, a casino operator, or slot machine manufacturer, could replace the reels associated with one payout table with another set of reels to adjust such payout factors as the hit frequency and return. Alternatively, the symbols on the reels could be made to be changeable. The payout rules could also be changed, but since the winning symbol combinations and their payout amounts are customarily posted on the machines, this is more difficult.

Often in some machines, the stopping positions were not all equally probable, either due to malfunction, wear, or manipulation by unscrupulous players shaking the machine or using magnets to make winning positions more probable. One attempt to solve this problem is shown in U.S. Patent No. 4,095,795 issued to Saxton et al. In a Saxton machine, following the pull of an arm or the press of a game start button, a computer simulates the rotation of the reels and uses a random number to determine the stopping position of the

simulated reels. The computer then controls the physical reels so that they stop at the positions determined by the simulated rotation. Because the stopping position of the reels is determined by a simulated rotation of the reels, a casino operator is assured that the payout characteristics will not vary from the payout characteristics dictated by the payout rules and the distribution of symbols on the reels; however, the casino operator is also not able to change these characteristics when desired.

One problem with mechanical reel machines and simulated mechanical reel machines is that the hit frequency and the return are limited by the distribution of symbols on the reels. In the above example, each of 8000 outcomes were equally likely. Therefore, a casino cannot offer a payout amount of 10,000 times a wager and still have a return of less than 100%, because the lowest probability for a particular combination of symbols is 1 in 8000 with a three reel, twenty position slot machine. In fact, the probability of any winning combination cannot be set to other than an integer multiple of 1/8000.

One slot machine, described in U.S. Patent 4,448,419, issued to Telnaes, uses virtual reel expansions to achieve lower probabilities than would be allowed by the physical reels used. In the Telnaes machine, the rotation of the reels is simulated, but the simulated reels contain more positions than the physical reel. To do this, some positions on a physical reel are mapped onto more than one position on the simulated reel. However, the hit frequency and return are still dependent on the simulated reels used. Therefore, in a dynamic environment, a casino operator would have to shut down a machine and replace its simulated reel strip to effect a different hit frequency and return. This is equivalent to a mechanical reel machine where some stopping positions are more likely by an integer multiple of the probability of other stopping positions occurring.

In a video gambling game, such as a video slot machine, the stopping positions are determined by simulating mechanical reel machines, as in the Saxton machine. In some

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environments, mechanical slot machines are more popular, in that they provide a player with a feel for an older mechanical reel machine, even if the outcomes are in reality determined by a computer.

One mechanical slot machine, described in U.S. Patent No. 4,573,681, issued to Okada, even goes so far as to simulate a player's ability to stop the reels at particular symbols. In an Okada machine, a computer uses a random number generator to determine a tentative payout amount. The machine spins the reels, and the player is allowed to press a button to stop each reel. When the button for a reel is pressed, the computer determines which symbol is in the window and decides whether that symbol will allow for the tentative payout amount. If it is, the reel is stopped on that symbol. If it is not, the reel is stopped on a nearby symbol. Although a player appears to be able to control the payouts, the actual return and hit frequency are fixed.

The theory of this machine is that a player will not notice that his or her chosen symbol is not actually being selected if a symbol within four symbols of the chosen symbol is selected. Instead, the player will attribute the wrong symbol being selected to pressing the button too soon or too late. In some cases, especially with the last reel, none of the nearby symbols will allow the tentative payout amount, and the machine is forced to pay out a different payout amount. In these cases, a payout consistent with the actual stopping positions of the reels is made and a bias is applied to the next game which is related to the difference between the tentative payout amount and the amount actually paid out. In this manner, the slot machine can maintain a pre-set return even though the player appears to have control over where the reels stop.

Gaming machines must also be easy to maintain, and given that gaming regulations change from time to time, casino operators need inexpensive ways to modify their existing machines to comply with new regulations.

One common maintenance problem with slot machines is the alignment of the reels. If a reel contains twenty

symbols, then a full reel is divided into 18 degree segments associated with each symbol. When a reel stops, one of those 18 degree segments should be centered in a viewing window which shows the final display. If the reels are not properly aligned, then a reel may stop such that half of each of two symbols will appear where a single, whole symbol should appear. On solution to the need for alignment of symbols is shown in U.S. Patent 5,102,136, issued to Heidel et al., in Figure 5 and column 4, lines 38-62 therein. That solution comprises a screw for adjusting the rotational position of a reel support which in turn adjusts the rotational position of the symbols on the reels supported by the reel support. However, is a complicated mechanical alignment mechanism and it relies of maintaining alignment between the symbols on the reels and the reels support.

SUMMARY OF THE INVENTION

The foregoing difficulties have been solved by the gaming machine according to the present invention described herein. In one embodiment, a gaming machine comprises various modules, such as a value acceptor for accepting coins, bills, tokens, or other indications of value which serve as wagers, a game start switch in the form of a push button or a pull arm, a game processor for determining the payout of a game and a final display consistent with that payout, a game display for displaying the final display at the end of a playing period, and a payout mechanism to provide indications of value to winning players, all enclosed within an enclosure which prevents unwanted manipulation. Each module is controlled by a separate processor, with well-defined interfaces between the modules. For example, if the gaming machine is a slot machine, each reel of the slot machine might be controlled by a reel processor which communicates with the game processor.

The use of a distributed processor system within a slot machine allows for synchronous events to occur without interrupting other processes which may be occurring, and also allows modules to be independently replaced, thus saving a casino operator considerable expense when the casino desires

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to replace a module, for maintenance, on the basis of feature popularity, or to comply with changing gaming regulations.

Furthermore, the modularity eliminates the need for all the modules to be in one location, and provides a manufacturer with a simple way to provide different variations of a machine for different jurisdictions. Other optional modules with their own processors include a light and sound processor and a network interface processor.

As an added advantage, illegal tampering with a gaming machine is made more difficult through the use of distributed processors, since a cheater would have to simultaneously disturb the operation of more than one processor, such as the reel processor and the game processor.

A particular embodiment of the invention is a mechanical reel slot machine with pull handle activation of a game. In this embodiment, the movements of the reels are controlled by stepper motors and the pull handle module includes a sensor to indicate when the pull handle is being pulled only slightly. When the pull handle is moved slightly, the stepper motors move the reels slightly, to suggest that a mechanical coupling exists between the pull handle and the reels. During the play of the game, the stepper motors rotate the reels and cause them to slow down and stop at the symbol combination of selected outcome, to simulate the frictional slowing of reels in a mechanical slot machine where the stopping position of the reels is determined by frictional forces.

With stepper motor control, the game processor can query the reel processor(s) to determine the orientation of the reels, and using a diagnostic system, a technician can direct the reel processors to step the stepper motors and record a position in order to align the reels such that symbols remain centered on a symbol display window.

Because the game processor determines the outcome of a game, and the probability distribution of payouts is independent of the distribution of symbols on the reels, a player can be provided a choice of different payout tables, such as a payout table that favors intermediate wins over big

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wins or a payout table with only big wins. In one particular embodiment, the payout table changes based on patterns of play. For example, the slot machine might use several payout tables during several test periods and note which payout tables result in the most play, or keep one player at the machine the longest. The length of time a player is at a machine can be guessed with reasonable accuracy from the timing of gaps between the end of a game and the start of the next game, as the gaps are generally longer between players than between two games played by the same player.

Additionally, the hit frequency and return can be manipulated by a machine owner/operator for a series of games or each game, while still allowing a random determination of a payout and a final display for any given game.

A further understanding of the nature and advantages of the inventions herein may be realized by reference to the remaining portions of the specification and the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a simplified perspective view of a slot machine according to the present invention;

Figure 2 is a simplified perspective view showing the handle mechanism of the slot machine in further detail;

Figure 3 is a front view of a slot machine reel, and associated hardware and circuitry;

Figure 4 is a side view of a slot machine reel showing its decoder ring and symbol sector and step divisions;

Figure 5 is a schematic diagram of the distributed processors of a slot machine;

Figure 6 is a board layout diagram of the electronic circuitry used to support the operation of the slot machine;

Figure 7 is a schematic diagram showing the game processor in further detail;

Figure 8 is a flowchart of a process implemented by a game processor of the slot machine; and

Figure 9 is a flowchart of an alternate process implemented by a game processor.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is not so constrained, but is described herein with reference to one very specific example of a gaming machine which is a slot machine with three reels, each reel having twenty stopping positions, each of which has associated with it a symbol. Of the twenty symbols on a reel, one is a bar symbol ("BAR"), three are cherry symbols ("CHERRY") and sixteen other symbols which do not contribute to a winning display. In an actual machine, the symbols and payout rules are likely to be more varied, to keep the interest of players, however this example is simplified so that the description is clear. It should be apparent that the concepts disclosed herein apply to any slot machine configuration, and any gaming machine configuration where the result of a game is shown by a display and the display needs to be consistent with a payout determined randomly according to probability distributions and a desired return and/or hit frequency, especially where the display is a display of symbols, such as those found on reels of slot machines or poker cards in a poker gaming machine, and the desired return and/or hit frequency are independent of the distribution of the symbols.

Figure 1 is a perspective view of a slot machine 100 according to the present invention. Slot machine 100 is shown including a coin acceptor 102, a handle 104, a play button 106, three reels 108, each of which shows a symbol 110 in a symbol window 111. Slot machine 100 is also shown including a cash out button 112, a pay-out rules selector 114, a pay-out rule display 116, a hopper tray 118, and a top box 122, all either enclosed within a slot machine enclosure 120 or attached thereto. Top box 122 further comprises lights 124 and a speaker 126.

To begin a game, a player inserts a coin into slot 102. As should be apparent, wagers can be collected in different ways such as a bill acceptor, a token acceptor, a ticket acceptor or an electronic value transferring systems to transfer value from the player to the casino operator for a wager. Once a wager has been made, the player will pull

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handle 104 in the direction indicated or press play button 106. When a game is initiated, reels 108 are set in to rotation. A game processor (not shown) determines, as explained below, what the outcome of the game will be. This determination occurs on the basis of random number calculations and can complete before the reels begin spinning or may be performed after the reels begin spinning. The outcome of the game is a payout and a final display. The internal electronics of slot machine 100 cause reels 108, usually one at a time, to stop on the symbols selected as the final display. A payout amount is then ejected from a hopper (not shown) into hopper tray 118 and, depending on the payout amount, lights 124 may be set to illuminate or flash and speaker 126 may be controlled so as to emit sounds accompanying a winning payout. The final display and the payout which form the outcome of the game are selected so as to be consistent with payout rules as specified on payout rule chart 116. Payout rule chart 116 as shown in Figure 1 indicates that a final display of three star symbols will receive a payout amount of one hundred times the wager and a final display of three cherry symbols will receive a payout of ten times the wager. As explained below, selector switches 114 are used to select different payout probability distributions. The ability for a player to select different probability distributions or payouts is one advantage provided by the present invention as a byproduct of the fact that the payout distributions are not made dependent upon the payout rules combined with the distribution of symbols 110 on reels 108. Figure 1 does not show the various electronic controls which control the switches, lights 124, speaker 126, reels 108 and handle 104; however, these are shown in detail in Figures 5, 6 and 7.

Figure 2 shows control and sensor mechanisms associated with handle 104. Handle 104 exits enclosure 120 at a bearing 202 and extends into enclosure 120 as a shaft 208. Coupled onto shaft 208 are a position sensor 204, which in some embodiments is a potentiometer, and a lever arm 206 on which is attached a strain gauge 210. Position sensor 204

communicates a position signal to a handle processor over signal lines 214 and strain gauge 210 communicates a strain of lever arm 206 to the handle processor over signal lines 212.

Figure 2 also shows a blocking shaft 216 controlled by a solenoid 218 to either block lever arm 206 or allow lever arm 206 to be rotated up to microswitch 222, whereupon lever arm 206 causes the contacts of microswitch 222 to contact, sending a game trigger signal to the handle processor over lines 224. The handle processor also controls solenoid 218 over signal lines 226 to either allow handle 104 to be pulled or to prevent handle 104 from being pulled.

As should be apparent from Figure 2, if a user pulls handle 104 while blocking arm 216 is blocking lever arm 206, lever arm 206 will become strained and such strain will be detected by strain gauge 210 and a corresponding signal will be sent over signal lines 212. Supporting base 220 is shown supporting solenoid 218. Supporting base 220 is fixedly connected to enclosure 120.

Figure 3 shows the mechanisms associated with each of reels 108 in further detail, including a stepper motor 302, a stepper motor driver circuit 304, a reel processor 306, a shaft 308 used to communicate rotational motion from stepper motor 302 to reel 108, a zero-detect sensor 310, a zero-detect tab 312 positioned to rotate through gap 314 in sensor 310 and an optical sensor 316 positioned to detect optical variations on decoding reel 318. The operation of optical sensor 316 with decoding reel 318 is shown more clearly in Figure 4.

With this arrangement, reel processor 306 is able to control the position of reel 108 to a resolution of one step of stepper motor 302 and can also detect the position of reel 108 using a zero-detect signal obtained from sensor 310 and a current symbol detect obtained from optical sensor 316.

Figure 4 is a side view of reel 108 with divisions between symbols indicated. In an actual reel, these divisions may or may not be present. The arrangement of light and dark areas on decoder ring 318 are shown in greater detail for only one symbol segment, S4. This symbol-indicating pattern 402 comprises dark framing lines 406 and a dark square in the

position designated with "4". Although it is not shown in Figure 4, each of the other segments of decoder reel 318 include patterns of light and dark spots separated by timing marks 406. The particular timing spots are indicative of the binary code for the number of the segment.

In this manner, reel 108 need be rotated through no more than one symbol segment to allow reel processor 306 to determine the position of reel 108. Should a power failure or malfunction occur such that reel processor 306 loses track of the position of reel 108, reel processor 306 need only send signals to stepper driver 304 to move reel 108 through the arc of a single symbol and reel processor 306 would then note the signal generated by optical sensor 316, convert it to a five-bit binary value, which would indicate which symbol segment is currently underneath optical sensor 316. Stepper marks 404 are also shown in Figure 4, although these are generally not included on the physical reel 108, but are shown in the figure to illustrate that stepper motor 302 is capable of stepping reel 108 through arcs much smaller than the arc defined by a symbol segment.

This ability is particularly useful when symbols 110 are not aligned in window 111. Using a diagnostic system, a technician can step reel 108 through a number of steps until symbols 110 are aligned in window 111. Once the reels are aligned, the diagnostic system notes the number of steps offset from a symbol sector boundary and provides that offset count to reel processor 306 and that count serves as an alignment offset, thus obviating the need for complex mechanical apparatus for keeping symbols aligned in window 111. Each reel processor maintains an alignment offset value for its reel.

Figure 5 is a schematic diagram of the distributed processors used to control various elements of slot machine 100. This is shown as distributed processor 500. Distributed processor 500 includes a game processor board 502, which is shown in greater detail in Figure 7, three reel processor boards which are discussed above in connection with Figure 3, a hopper processor 504, a door I/O processor 506, a handle

processor 508, a top box processor 510, a value acceptor processor 512, and an optional network I/O processor 514.

Each of these processors communicates with other processors over an RS485 bus 516. To communicate over the RS485 bus, one processor submits a message to the bus addressed to another processor in an asynchronous fashion. Because of this arrangement, each processor can perform its function without being interrupted by the events which may asynchronously occur on the inputs of other processors. For example, game processor board 502 accepts commands from a casino operator and also outputs a coin escrow display, while reel processor board 306 outputs stepper motor control signals and accepts zero detect signals and current symbol detect signals from reel sensors. The processing of zero detect signals and current symbol detect signals can be performed independent of the actions being performed by the game processor.

For security purposes, all messages on the RS485 bus are encrypted by the sender and decrypted by the receiver. Any number of encryption schemes can be used, such as a public key or a challenge-response encryption process which assumes that a undesired listener is monitoring all traffic on the bus.

Similarly, hopper processor 504 accepts inputs and provides outputs specific to the hopper, such as accepting a signal from hopper hardware indicative of the hopper being full and sending out signals to cause the hopper to release coins into hopper tray 118.

Door I/O processor 506 controls the door and security related functions as well as button sensing. Thus, the depression of payout distribution select button 114 and play button 106 are detected by door I/O processor 506. If slot machine 100 is provided with security devices such as door opening sensors and tamper detect sensors or tilt detect sensors, those inputs are provided to door I/O processor. Because of the distributed nature of the processors, it is much more difficult to fraudulently manipulate the internals of slot machine 100. In the prior art, where a single

processor is used to control all aspects of the machine, it would be a relatively simple matter for a cheater, once the slot machine door is open, to control the outputs of such a central processor.

Handle processor 508 controls all aspects of I/O with handle circuitry shown in Figure 2, such as an indication of the strain provided on lever 206, the position of the handle and an output to release the handle as well as a game start trigger provided by microswitch 222.

The present invention, handle processor 508 detects movement of handle 104 even where such movement may be less than the full travel of handle 104 and sends messages to reel processor boards 306 and reel processor boards 306 respond to such messages by sending stepper motor control signals to stepper driver 304 to move reels 108 slightly. This provides the apparent effect of handle 104 "jiggling" reels 108 as if they were mechanically coupled.

Top box processor 510 controls lights 124 and speaker 126 such that when game processor board 502 sends a payout message to top box processor 510, the top box processor will activate lights 124 and cause speaker 126 to emit sounds corresponding to the payout. For example, with a small payout, the lights might blink once or twice and with a large payout, the lights might flash repeatedly and a loud siren sound might be emitted from speaker 126.

Value acceptor processor 512 receives a signal indicating that a valid coin or other value indicator has been accepted as a wager and also controls value accepting mechanisms to prevent value from being accepted in such cases where hopper processor 504 has sent a message indicating that the hopper is full or game processor 502 has sent a message indicating that slot machine 100 has malfunctioned.

Another example of processor-to-processor communication is where a player presses cash-out button 112. Pressing button 112 causes a signal to be sent to door I/O processor 506 which debounces the button signal, if necessary, and packages a message to be sent over bus 516 to game processor board 502. When the message is received by game

processor 502, it reduces a stored coin escrow value to zero, which will cause the coin escrow display to display zero. The game processor board then sends a message to hopper processor 504 indicating a number of coins or other value indicators to be released to the player, which hopper processor 504 converts into signals sent to coin circuitry for releasing coins into hopper tray 118.

An optional network I/O processor 512 is also provided in some embodiments to allow casino operator commands to be sent over an external network as well as to allow a remote query of a status total and diagnostic data from slot machine 100.

Because of the modularity of the processors, some of the functionality of the processors and the associated mechanical devices can be located in the base which supports slot machine 100. For security purposes, enclosure 120 would be securely attached to any such base, such as base 130 shown in Figure 1. If much of the internal electronics and mechanical devices of slot machine 100 can be housed in base 130, then slot machine enclosure 120 can be made much smaller. One appeal of a smaller slot machine is that many players are comfortable with smaller slot machines, which have a more "friendly" feel to them.

Figure 6 is a wiring layout showing how various independent processor boards might be coupled.

Figure 7 is a more detailed schematic diagram of game processor board 502, showing a central processing unit (CPU) 702, a read-only memory (ROM) 704, an erasable programmable ROM (EPROM) 706, a random access memory (RAM) 708, a random number generator 710 and a clock 712. As shown, CPU 702 communicates with the RS485 bus, accepts external commands and provides data to an external monitor, as well as being connected to ROM 704, EPROM 706, RAM 708, random number generator 710 and clock 712. Clock 712 is also optionally coupled to random number generator 710 for those embodiments where the random number generated depends on a time component. CPU 702 is also shown with a coin escrow count display output for providing a display of the number of coins in escrow,

which are displayed on coin escrow count display 128 (see Figure 1).

ROM 704 is used to store the operating program which CPU 702 executes to perform the various functions described herein. ROM 704 also stores predefined payout tables, a default display table, and other constants as necessary as explained herein.

EPROM 706 stores alternate predefined payout tables, an alternate display table, as well as default values for a return and a hit frequency.

Figure 8 shows one example of a process game processor 502 might use to control a game. The flow chart of Figure 8 is shown with a starting block 802 and flow continuing through blocks 804, 806, 808, 810, 812, 814, 816, 818, 820, 822 and 824. The process flows from one block to the next higher numbered block unless indicated otherwise.

At block 804, game processor 502 waits for a game initiation signal. A game initiation signal is either a message from door I/O processor indicating that play button 106 has been pressed or a message from handle processor 508 indicating that microswitch 222 has been tripped. Of course, a number of other will known methods of initiating a game could be used.

At block 806, game processor 502 determines whether a wager has been made. A wager could be assumed from a non-zero coin escrow count or a wager might be indicated by a message from value acceptor processor 512 indicating that a valid coin or other indicator of value has been inserted into slot machine 100. If a wager has not been made, game processor 502 loops back to block 806 until a wager has been made, at which point game processor 502 proceeds to block 808.

At block 808, game processor 502 calculates a current payout table, if not already calculated, and stores it in either RAM 708 or EPROM 706. As should be apparent to one skilled in the art, RAM 708 could maintain a pointer to one of multiple payout tables. Tables 1(a)-(c) below describe some exemplary payout tables.

A payout table defines a number of payouts, each labelled with a label such as "Win A", "Win B", "Loss", etc. For each possible payout, the payout table defines the probability of occurrence of that payout, and a payout amount. Although each table below includes a column for expectation value, this need not be stored, since it can be calculated from the payout amount and the probability, and in any case, the expectation value, as such, is not used by game processor 502.

A payout table also inherently defines a hit frequency and a return, which are highlighted in Tables 1(a)-(c). The highlighted cell of the probability column, the probability of a losing game, is of course, one minus the hit frequency, and the return is the total for the expectation value column. The numbers in each of these tables are shown to four decimal places, although in practice the numbers have a resolution of 32 bits, which is enough to express numbers between 0.0 and 1.0 to about 9 decimal places.

The first table, Table 1(a), is a payout table for an intermediate payout distribution, in which intermediate payouts, such as "Win C" have a high probability. This game is preferred by customers who would rather win more often than win a big jackpot rarely.

Label	Payout	Probability	Expectation Value
Win A	1000	0.0001	0.1000
Win B	100	0.0009	0.0900
Win C	10	0.0440	0.4400
Win D	2	0.1550	0.3100
Loss	0	0.8000	0.0000
Totals		1.0000	0.9400

TABLE 1(a). Intermediate Distribution Payout Table

Note that, unlike the prior art, there is no constraint that the probabilities be multiples of some distribution function of the symbols on the reels, such as 1/8000 (0.000125) in the case of a three twenty-position reel

slot machine where the payout probability distribution is determined by the symbols on the reels and payout rules. Table 1(a) only contains numbers which are whole multiples of 0.0001, but this is not a constraint of the invention, but was done to keep the table uncluttered. As should be apparent, the probabilities could be settable in an actual gaming machine according to the present invention with a resolution of 32 bits, i.e., constrained only to be multiples of 2^{-32}. Some embodiments may have more or less resolution.

As should also be apparent, a payout table need not be fixed. Game processor 502 could read a fixed payout table from ROM 704, or could read a return and hit frequency from ROM 704, EPROM 706 or RAM 708 (although the latter is unlikely) and calculate a payout table. The calculated payout table is then stored in EPROM 706 or RAM 708 until the game processor 502 is instructed to recalculate the payout table.

Table 1(b) is a payout table for a jackpot distribution. Using this payout table, payouts such as "Win A", a "jackpot" win are more likely. To keep the total return and hit frequency the same, the intermediate payouts are made less likely. Note that the probability of the payout with the smallest nonzero (i.e., winning) payout amount is greater than in the intermediate distribution payout table. This is to keep the hit frequency constant.

Label	Payout	Probability	Expectation Value
Win A	1000	0.0005	0.5000
Win B	100	0.0001	0.0100
Win C	10	0.0039	0.0390
Win D	2	0.1955	0.3910
Loss	0	0.8000	0.0000
Totals		1.0000	0.9400

TABLE 1(b). Jackpot Distribution Payout Table

Another type of payout table is one with a payout distribution such that each payout has an equal payout amount expectation value. This payout table is favored by some

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players and casino operators because the probability of each payout is inversely proportional to the payout amount. Table 1(c) shows how such a payout table can be calculated using just the payout rules (which define the payout amounts for each payout), the hit frequency and the return. The variable E is a placeholder for the calculation.

Label	Payout	Probability	Expectation Value
Win A	1000	E/1000	E
Win B	100	E/100	E
Win C	10	E/10	E
Win D	2	(R-3E)/2	R-3E
Loss	0	1 - HF	0.0000
Totals		1.0000	R

TABLE 1(c). Even Expectation Value Payout Table

As should be apparent from Table 1(c), the payout table can be calculated from the return R, the hit frequency HF, and the payout rules (which specify payout amounts of 1000, 100, 10 and 2). For some payout rules, there is no solution which allows all the expectation values to be equal. Although there are payout rules for which this is possible, it is more sensible to allow one of the winning payouts to have what is, in a sense, a remainder expectation value, R-3E. Even if one of the payouts has a different expectation value, it is nonetheless still considered an even payout table. If one payout expectation value (in this example, the last winning payout) is not constrained to be equal to the others, then a solution can always be found. In the above example, E is found from the equation E/1000 + E/100 + E/10 + (R-3E)/2 = HF, which simplifies to E = ((500 x R) - (1000 x HF))/1389. With R = 0.94 and HF = 0.20, E is 270/1389, or approximately 0.1944.

In fact, a payout table can be calculated for any desired relative probabilities for three of the payouts shown above (or in general, for n-1 payouts where the payout rules specify n winning payouts). Significantly, any of the above

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tables can be used with any given slot machine, without the need to modify the reels or the symbols on the reels, so long as the payout rules do not specify a payout for a symbol combination which is not possible with the reels used. In other words, the reels must include at least one display consistent with each payout if the probability of that payout is greater than zero.

Once a payout table is generated, game processor 502 proceeds to block 810 and generates a game random number (GRN) used to randomly select one of the payouts. GRN is generated by random number generator 710 by any one of the well known methods for generating a random number from a uniform, normalized distribution. In some embodiments, a time signal from clock 712 is used as part of a seed so that a player who studies a slot machine's behavior and knows how it calculates random numbers will not be able to determine the next random number from a discovered sequence.

At block 812, the GRN is used to select one of the payouts in any manner well known to one skilled in the art for randomly selecting one member of a plurality of members in a set where a probability is associated with each member. One method is to map each payout to a range of possible values of GRN with each range proportional to the probability for that payout. For example, in the above payout tables the losing payout has a probability of 0.8. If GRN is a random variable selected from a uniform distribution from 0.0 and 1.0, then a GRN between 0.0 and 0.8 could be designated as a selection of the losing payout.

At block 814, the payout amount for the selected payout is determined from the current payout table. In alternate embodiments, the payout amount is not determined until after block 820, as the payout amount is not needed until a payout amount message is to be sent to the top box processor to present an audio-visual display corresponding to the amount won and to the hopper processor to pay out the amount won.

Once a payout is selected, a final display consistent with that payout needs to be selected. Of course,

slot machine 100 needs only to display one consistent final display for each payout, but to keep the game interesting, slot machine 100 randomly selects a final display from the set of possible consistent displays. This selection is done using a look up table which indicates which final displays are consistent with which payouts. An example is shown by Table 2.

Payout	Display #	Reel 1	Reel 2	Reel 3
Win A	1	BAR	BAR	BAR
Win B	1	BAR	BAR	CHERRY1
	2	BAR	BAR	CHERRY2
	...	...	...	...
	19	BAR	BAR	X16
	20	BAR	CHERRY1	BAR
	...	...	...	...
	56	X15	BAR	BAR
	57	X16	BAR	BAR
Win C	1	BAR	CHERRY1	CHERRY1
	2	BAR	CHERRY1	CHERRY2
	3	BAR	CHERRY1	CHERRY3
	4	BAR	CHERRY1	X1
	...	...	...	...
	1142	X16	X16	BAR
Win D	1	CHERRY1	CHERRY1	X1
	2	CHERRY1	CHERRY1	X2
	...	...	...	...
	324	X16	CHERRY3	CHERRY3
Lose	1	CHERRY1	X1	X1
	...	...	...	...
	6476	X16	X16	X16

TABLE 2. Possible Displays

Table 2 lists all 8000 possible displays for a three reel, twenty position slot machine. While some of the entries might appear to be the same final display because of symbols being repeated on the reels, the display is different if the player can see the edges of adjacent symbols and the adjacent symbols are different. For a gaming machine in which the final display is a poker hand, the number of final displays is 52 x 51 x 50 x 49 x 48, or 311,875,200. With that number of combinations, the final display selection might not be table-based, but instead could be rule-based. Of course, even with 8000 displays, a rule-based display selection might also be possible.

Table 2 above is the table of final displays for a slot machine where each of three reels include one BAR symbols, three cherry symbols, and sixteen symbols which do not contribute to a winning display. In this example, the payout rules are a final display of three BAR symbols results in payout "Win A", two BAR symbols results in payout "Win B", one BAR results in payout "Win C", two CHERRY symbols result in payout "Win D", and all other symbol combinations result in payout "Lose". Of course, with the present invention, the payout does not "result" from the final displays, since the payout is selected first and a consistent display is selected, although it appears to the player that the display is determined first and then the consistent payout is determined.

The particular payout rules represented in Table 2 allow for an ambiguous payout, namely the symbol combinations of one BAR and two CHERRY symbols, which are consistent with either payout "Win C" or payout "Win D". In this case, an additional payout rule is that the player will obtain the highest payout for the display. Another way of handling this ambiguity is to simply not include those displays as possible displays, which is trivial given that the payouts are determined before the displays in the present invention. However, the latter approach is not useful with the given payout rules, since a display of three BAR symbols is consistent with the first three payouts.

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If the payout is "Win A", then there is only one display to choose from, and that is set to be the final display. If the payout is "Win B", the number of consistent displays, n_b, is 57. In a basic embodiment of the invention, each of the 57 displays are assigned a probability of 1/57 (uniform distribution).

These symbol selections highlight a benefit of the present invention, which is that the payout table is independent of the display table. In the prior art, where they are dependent and each display has an equal probability, the hit frequency for Table 2 and the payout rules of Tables 1(a)-(c) would be fixed at 1524/8000, or 19.05%, and the return would be fixed at 235%! The intermediate win payout out of ten would also be three times as likely as the low win payout out of two. The casino operator using the present invention has no such constraints.

It should be apparent that the display table is not required, but is only used to vary the different possible consistent displays. In one embodiment, albeit a less interesting embodiment, only one display is used for each payout. Once the payout is selected, that one display is the selected display. The advantage to this embodiment is that it takes less computing power, since the random number for selecting the display need not be generated and Table 2 need not be created or stored in memory.

In another variation, a table such as Table 2 (or a table in which the sequence of displays is less orderly) is used, but the display selected from the plurality of consistent displays is not randomly selected. Instead, the display is selected according to a deterministic rule. For example, game processor 502 might store pointers to the last display selected of each group of consistent displays, and select the next consistent display. One advantage to this embodiment is that an unscrupulous player watching the reels for an extended time would notice the pattern of displays and attempt to determine when the high payouts will occur. Of course, since the payout determination is totally independent

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of the display determination, no information about a payout can be found from the display.

Referring again to Figure 8, at block 816, a display random number (DRN) is randomly generated, and is used to randomly select one of the displays consistent with the payout. For example, if the payout is "Win B", then DRN would cause one of the 57 displays consistent with a "Win B" to be selected. In an alternate embodiment, DRN can be derived from a portion of GRN. For example, after selecting a payout, GRN can be normalized such that GRN is evenly distributed over the range of numbers associated with a payout are normalized to a range of 0.0 to 1.0.

Once the final display is selected, game processor 502 sends a final display message indicating the final display to reel processors 306 over bus 516, at block 818. The reel processors then determine where each reel should stop. To present a pleasing game, each of reel processors 306 slows its reel 108 down before stopping it on the final symbol, and reel processor 306(1) stops reel 108(1) before reel processor 306(2) stops reel 108(2), and reel processor 306(2) stops reel 108(2) before reel processor 306(3) stops reel 108(3). In order to coordinate this, the reel processors send messages to each other over bus 516.

At block 820, game processor 502 waits for all the reel processors to send messages indicating that they have stopped their reels, and then at block 822, game processor 502 sends a payout message to top box processor 510, and at block 824 sends the payout message to hopper processor 504. The payout is known before the reels stop, but to create the impression in the player's mind that the display is not selected to conform to an already determined payout, the top box and the hopper do not react until after the final display is presented.

The top box processor causes lights 124 to flash and speaker 126 to emit sounds associated with the payout. Typically, the speaker is silent for a loss and is progressively louder for larger payout amounts, and the amount

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of visual stimulus provided by lights 124 is similarly related to the payout amount.

The hopper processor uses the payout amount message to determine how many coins or indications of value to provide to the player. If a gaming machine is so configured, no value is provided at that time to the player, but an escrow account balance is increased. Typically, the balance of the escrow account is paid out through the hopper when "CASH OUT" button 112 is pressed.

Following block 824, game processor 502 resets for the next game, and the process flows back to block 804. In the process just described, the payout and the final display are not determined until a game has started and a wager is made. In an alternate embodiment, the outcome of a next game is determined before that game begins, however this is not the preferred order, since it might allow a player with access to the internals of a slot machine to determine if the machine is set to win before the player makes a wager.

Figure 9 is a flowchart 900 which is an alternate description of a process for operating a slot machine. The process begins when a player makes a wager and initiates a game (step 902) by either pressing a start button or by pulling a handle. Once a game starts, and preferably after the reels begin spinning to limit opportunities for fraud, the game processor generates a first random number, RN1 (step 904).

The generation of RN1 is performed according to well known methods for generating random numbers. In a specific embodiment, RN1 is a 32-bit number randomly selected from all possible 32-bit numbers with each 32-bit number being equally likely. To fall between the range from zero to one, the 32-bit value is simply treated as the binary fractional portion of a number.

Once RN1 is generated, it is checked against HF, the hit frequency value for the game (step 906). In the specific embodiment HF is a 32-bit value between zero and one, and HF is settable by the owner of the gaming machine implementing this process. In one specific machine, the hit frequency is a

32-bit approximation of 0.20. If RN1 is less than HF, indicating that the game is a winning game, the process continues at step 910, otherwise, the game is a losing game and the process continues at step 908.

If the game is a winning game, a second random number, RN2, is generated (910), and is used to select a payout from a payout distribution (912). Using a random number to select one member of a set based on a probability distribution of the members is well known in the art, as explained above. In a specific embodiment, the probability distribution of payouts is described by an ordered array of payout records, wherein each record has two fields, an identifying field identifying the payout and a sum field which holds the sum of the payout's probability and the sum of probabilities of all other payouts which are prior to the payout in the ordered array. This way, the game processor need only scan through the ordered array once to select the first payout whose sum field is greater than RN2. The effect of this operation is to select a payout based on the payout probability distribution, with the selected payout determined by RN2.

The probability distribution of the payouts determines the return percentage for the game, as explained above. Significantly, the probability distribution of the payouts is not constrained at all by the distribution of symbols on the reels, or in any other way determined by the final display, since the final display is determined after the payout is selected.

If the game is a losing game, as determined in step 906, the process continues with step 908, where the one losing payout (typically having a payout amount of zero, or some small consolation prize which may or may not be money) is selected.

Whether the game is a winning game or a losing game, a third random number, RN3, is generated (step 914), and the game processor uses RN3 to select one display from a set of consistent displays (916). The probability distribution of displays within a set of consistent displays can either be a

uniform distribution (each display equally likely) or a non-uniform distribution (some displays are favored, such as "near-miss" displays). The determination of which displays are consistent with which payouts is a straightforward exercise as described above.

Once a final display is selected, the game processor causes the reel processors to control the reels so that the reels stop in a position which displays the selected display (918). If a winning game was hit (as determined in step 906), decision step 920 directs the process to step 922, otherwise the game ends. At step 922, the player is credited with the payout amount associated with the selected payout, and then the game ends. In some embodiments, when the game is a losing game and the payout is not zero, the player is provided with the consolation prize.

In summary, this description describes gaming machines, slot machines in particular, where a payout is selected according to a payout distribution independent of the distribution of symbols used for the possible displays, and a final display is selected from a set of displays consistent with the selected payout. The gaming machine is arranged so that it appears to a player that the display is determined before the payout, and in the case of slot machines, that the stopping positions of the reels are determined by the random effects of friction, as was the case with older, purely mechanical slot machines.

Furthermore, a slot machine is described where an electronic linkage is provided between the handle and the reels to simulate the mechanical linkage of older machines. A reel decoding apparatus and method are also described which allows a reel processor to determine a reel position independently of a count of steps of a stepper motor without needing to rotate the reels to a zero position indicator. A distributed processing system for controlling various aspects of the slot machine, with many advantages is also disclosed.

The above description is illustrative and not restrictive. Many variations of the invention will become apparent to those of skill in the art upon review of this

disclosure. Merely by way of example, the probability distribution of displays need not be a uniform distribution over all consistent displays, but need only be zero for each inconsistent display, such as a distribution which favors (makes more probable) losing displays which are adjacent to winning symbols, to create "near-miss" displays. The scope of the invention should, therefore, be determined not with reference to the above description, but instead should be determined with reference to the appended claims along with their full scope of equivalents.

Appendix A is a source code listing of a program used to control a programmed computer according to the present invention. The program is written in the C programming language, and can be compiled with a C compiler as is well known in the art. In a particular embodiment, the complied code is stored in ROM 704 and is executed by CPU 702 to perform steps shown in the flowchart of Figure 8.

Source Code Appendix A

```
/*  Copyright 1994 Spintek International, Inc.

     The game algorithm of this machine is based on the
equation:

   HF*(p1*pay1 + p2*pay2 +...+ pN*payN) = PC*CP

   where CP is Coins Played
         PC is desired game return percentage
         HF is desired game hit frequency

     pN is the probability of winning payN, which we have
selected to be the lowest payout amount, LP.  pN equals 1
minus the sum of the other probabilities since the sum of the
probabilities must equal 1.  In equation form, this is:

     pN = 1 - (p1 + p2 +...+ pN-1)

and it follows that

     pN*payN = 1*payN - (p1*payN + p2*payN +...+ pN-1*payN)

and

     HF*[(p1*(pay1-payN))+(p2*(pay2-payN))+...+1*payN] = PC*CP.

The win percentages (i.e., values for p1, p2, ..., pN-1) for
an even expectation value payout table are calculated by
finding the value of the sum of:

   (p1*(pay1-payN)) + (p2*(pay2-payN)) +...

and dividing that sum equally amongst the payouts thus giving
each payout approximately equal expectation.  The first win
percentage is then:

   p1=[(((CP*PC)/HF)-LP)/(NP-1)]/(pay1-payN)

and the others are similarly calculated.  The subroutine
load_win_percentage() is called on power up, upon entry of a
new game return percentage value or hit frequency value.

load_win_percentage() calculates the values to be entered into
the payout table, which is the array win_percentage[][] here.
An intermediate double float value, d, is calculated first to
limit multiple recalculation of common factors.  The equation
for d is:

   d=(((CP*PC)/HF)-LP)/(NP-1)

   where CP is Coins Played
         PC is desired game return percentage
         HF is desired game hit frequency
         LP is the lowest nonzero payout amount and
         NP is the number of nonzero payouts (including LP).
```

```
The variable d is converted to a 32 bit fraction, w, and win
percentages are calculated as (w/(pay-LP)) + the sum of the
previously calculated win percentages to allow a simple table
search.  The last table value (associated with the lowest pay,
LP) is arbitrarily set equal to 0xFFFFFFFF, which is the
maximum value of a random number in this system.
*/

void load_win_percentage (void)
{
double d;
unsigned long w;
unsigned long sum;
int i;
int j;

   for (i=0; i<max_coins; i++){

      sum=0;

      d = ((double) (((unsigned long) (i+1)) * desired_pc));
      d /= ((double) hit_frequency_pc);
      d -= ((double) payout_amt[i][number_of_payouts-1]);
      d /= ((double) (number_of_payouts-1));

      w = (unsigned long) (0xFFFFFFFF*d);

      for (j=0; j<(number_of_payouts-1); j++){

         sum += (w/((unsigned long)(payout_amt[i][j]
                  - payout_amt[i][number_of_payouts-1])));

         win_percentage[i][j]=sum;
      }

      win_percentage[i][number_of_payouts-1]=0xFFFFFFFF;
   }
}

/*
     Game play outcome is determined by a single call to the
subroutine generate_game_result().  This subroutine calls a
pseudo-random number generator subroutine which returns a 32
bit unsigned long integer in the range [0, 0xFFFFFFFF].  The
random number is compared with the unsigned long integer
hit_frequency.  If the random number is less than or equal to
hit_frequency, the game is a winner.  If the game is a winner,
a second random number is generated which is compared with the
values in the payout table (win_percentage[][]) starting with
the lowest payout amount.  When a win_percentage table value
is found that is greater than the random number, the
corresponding pay amount and symbol combination set is
selected as the game outcome.

     If the game is a loser, the payout amount is set to zero
and a losing symbol combination set is selected.
*/
```

```
void generate_game_result(void)
{
unsigned long r;
int i;
int j;
unsigned char code *combo;

   if(rng()<=hit_frequency){ /* WINNER*/

      r=rng();  /* Get second random number*/

      /* Assume lowest pay */

      pay_amount =
         payout_amt[coins_played-1][number_of_payouts-1]

      combo =
         get_pay_combination_ptr(machine_selection,
                                 number_of_payouts-1);

/* Compare random number with win percentages */

      for (i=0; i<number_of_payouts-1; i++){

         if(r<=win_percentage[coins_played-1][i]){
            pay_amount =
               payout_amt[coins_played-1][i];
            combo =
               get_pay_combination_ptr(machine_selection,i);
            break;
            }
         }
      }

   else{  /* LOSER /*
/* Use zero pay amount and a consistent symbol combination. */

      pay_amount=0;
      combo=get_pay_combination_ptr(machine_selection,
                                    number_of_payouts);
      }

   for (j=0; j<number_of_reels; j++) {
      display_combination[j] = (*combo);
      display_position[j] =
            get_reel_strip_position(machine_selection,
                                    display_combination[j]);
      combo++;
      }

/* Do accounting functions */

   coin_in_meter+=coins_played;
   coin_out_meter+=pay_amount;
   actual_percentage=(100*coin_out_meter)/coin_in_meter;
}
```

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WHAT IS CLAIMED IS:

1. A gaming machine comprising:

a value acceptor for accepting indications of value from a player;

game initiating means, coupled to said value acceptor, for initiating a game when said indication of value has been accepted;

game processing means, coupled to said game initiating means, for determining an outcome of said game, said outcome defining at least a payout;

game display means, coupled to said game processing means, for displaying, over a nonzero time, a progression of said game ending with a final display consistent, according to predetermined payout rules, a payout amount of said payout;

payout means, coupled to either said game processing means or said game display means, for providing value to said player consistent with said payout amount;

a slot machine enclosure enclosing said value acceptor, said game initiating means, said game display means, and said payout means; and

a plurality of processors, at least one in each of said value acceptor, said game processor, said game display means, and said slot machine enclosure, each of said plurality of processors including an independently operating central processing unit, thereby allowing each processor to be reconfigurable and replaceable without requiring reconfiguration of other processors.

2. The gaming machine of claim 1, wherein said outcome defines said payout amount and said final display.

3. The gaming machine of claim 1, wherein said value acceptor and said payout means operate on different forms of value selected from coins, bills, tokens, scrip, or electronic credits and debits.

4. The gaming machine of claim 1, wherein said game display means is one of a plurality of reels rotating about a

common axis or a video screen which simulates plurality of reels rotating about said common axis.

5. The gaming machine of claim 4, wherein said display means is programmed to rotate said reels of simulated reels during said nonzero time, stopping said reels or simulated reels one at a time until said final display is reached.

6. The gaming machine of claim 1, wherein the gaming machine is a slot machine.

7. The gaming machine of claim 1, wherein the game processing means determines a payout according to a payout table, said payout table selectable by a player from a plurality of possible payout tables.

8. A slot machine comprising:

a plurality of reels mounted to rotate about a common axis;

a game processor for determining final position for said plurality of reels;

a handle coupled to said game processor and positioned to allow handle movement by a player such that when said handle is moved from a resting position to a full rotation position, said game processor initiates rotation of said reels; and

a sensor coupled between said handle and said game processor for detecting travel of said handle between said resting position and said full rotation position, wherein said sensor provides said game processor with an indication of a distance of said detected travel.

9. The slot machine of claim 8, wherein said game processor is programmed to move one or more of said plurality of reels through an angular distance of less than a full rotation when said sensor provides an indication that said

handle is moved through less than said travel between said resting and full rotation positions.

10. The slot machine of claim 8, wherein said game processor comprises a plurality of processors, including one processor per reel of said plurality of reels.

11. A slot machine comprising:

a plurality of reels mounted to rotate about a common axis;

a game processor for determining a final position for said plurality of reels;

a plurality of stepper motors, at least one per reel of said plurality of reels, each stepper motor controlled by said game processor;

wherein said game processor is programmed to slow the rotation of a reel using the stepper motor until said reel is stopped at a predetermined angular position, to simulate a frictional slowing of said reel.

12. A slot machine comprising:

a plurality of reels mounted to rotate about a common axis;

a game processor for determining final position for said plurality of reels;

a plurality of stepper motors, at least one per reel of said plurality of reels, each stepper motor controlled by said game processor;

means for indicating an alignment offset position of a reel;

memory coupled to either said game processor or a reel processor dedicated to control of one or more of said plurality of reels,

wherein said memory stores said alignment offset position and wherein said game processor or said reel processor uses said alignment offset position to control said stepper motor.

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13. The slot machine of claim 12, wherein said game processor or said reel processor is programmed to stop said plurality of reels at positions offset by said alignment offset position, thereby providing each of said plurality of reels with an angular rotation necessary to keep a symbol centered in a display window.

14. The slot machine of claim 12, further comprising means coupled to said game processor for generating an electronic signal when a reel is in a zero position, said reel having one zero position with a known spatial relationship to centers of symbols on said reel.

15. A method of operating a gaming machine, wherein a game begins with a wager and the gaming machine provides a player with payout rules, the method comprising the steps of:

randomly selecting a payout from a plurality of payouts according to a probability distribution of said plurality of payouts;

then, randomly selecting a display from a set of displays which are consistent with the payout rules and said selected payout;

displaying said selected display; and

crediting the player with a payout amount of said selected payout.

16. The method of claim 15, wherein one of said plurality of payout has a payout amount of zero and is associated with a losing game.

17. The method of claim 15, further comprising the steps of:

associating sets of combinations of symbols with each of said payouts, thereby defining payout rules,

wherein each display in said set of displays comprises a combination of symbols, and wherein a given display is consistent with a given payout if and only if said

given display comprises a combination of symbols which is a member of a set associated with said given payout.

18. The method of claim 15, wherein said combinations of symbols are poker hands.

19. The method of claim 15, further comprising the step of stopping a plurality of reels in stopping positions to display said selected display, said stopping positions being such that said plurality of reels display, in a window, the combination of symbols which the selected display comprises.

20. The method of claim 15, wherein said probability distribution of displays is a uniform probability distribution over all displays consistent with said selected payout.

21. A method of operating a gaming machine, wherein a game begins with a wager and the gaming machine provides a player with payout rules, the method comprising the steps of:

randomly selecting a payout from a plurality of payouts according to a payout probability distribution of said plurality of payouts, wherein said step of randomly selecting a payout is performed without reference to a distribution of symbols on a display;

then, selecting a display from a set of displays which are consistent with the payout rules and said selected payout;

displaying said selected display; and

crediting the player with a payout amount of said selected payout.

22. The method of claim 21, wherein only one display in said set of displays is consistent with the payout rules and said selected payout, thereby reducing said step of selecting a display to a step of identifying said only one display.

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23. The method of claim 21, wherein said step of selecting a display is a step of randomly selecting one display consistent with said selected payout from said set of displays when said set of displays comprises a plurality of displays consistent with said selected payout.

24. The method of claim 21, wherein said step of selecting a display is a step of selecting one display consistent with said selected payout from said set of displays when said set of displays comprises a plurality of displays consistent with said selected payout, wherein said one display is determined unambiguously from said selected payout and a predetermined rule.

25. The method of claim 21, wherein said step of randomly selecting a payout comprises the steps of:

determining said plurality of payouts;

associating each payout amount of a plurality of payout amounts with each payout of said plurality of payouts;

calculating a return percentage for said plurality of payouts as a weighted sum of said each payout amount weighted by a payout probability of said associated payout, said payout probability determined according to said payout probability distribution;

adjusting one of said payout probability distribution or said plurality of payout amounts when said return percentage is other than a desired return percentage to reduce a difference of said return percentage and said desired return percentage; and

randomly selecting said payout according to results of said step of adjusting.

26. The method of claim 25, wherein said step of calculating said return percentage comprises the steps of first calculating a hold percentage and then subtracting said hold percentage from one to result in said return percentage.

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27. The method of claim 25, wherein said step of step of calculating is performed each time a game is played.

28. The method of claim 25, wherein said step of step of calculating is performed whenever a gaming machine operator desires to adjust said hit frequency or said return percentage, the method further comprising a step of accepting a new value for said hit frequency or said return percentage from said gaming machine operator, thereby creating a payout probability distribution reflecting any adjustments to said hit frequency or said return percentage.

29. The method of claim 21, wherein said step of randomly selecting a payout comprises the steps of:

determining said plurality of payouts;

calculating a hit frequency for said plurality of payouts as a sum of probabilities of payouts which result in a nonzero payout amount, said probabilities determined according to said payout probability distribution;

adjusting said payout probability distribution when said hit frequency is other than a desired hit frequency to reduce a difference of said hit frequency and said desired hit frequency; and

randomly selecting said payout according to results of said step of adjusting.

30. The method of claim 29, wherein said step of step of calculating is performed each time a game is played.

31. The method of claim 21, wherein said plurality of payouts includes only winning payouts and the method further comprising a step of randomly selecting between a winning game and a losing game according to a hit frequency value, followed by said step of randomly selecting a payout from among said winning payouts only when said winning game is selected.

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32. The method of claim 21, wherein plurality of payouts includes only winning payouts and the method further comprising a step of randomly selecting between a winning outcome and a losing outcome according to a hit frequency value, followed by said step of randomly selecting a payout from among said winning payouts.

33. The method of claim 32, wherein said hit frequency value is a value between zero and one, wherein an expectation value of a payout amount over said plurality of winning payouts multiplied by said hit frequency value is a return value between zero and one.

34. A method of operating a gaming machine, wherein a game begins with a wager and the gaming machine provides a player with payout rules, the method comprising the steps of:

generating a first random number;

selecting a game result from a hit and a non-hit according to a hit frequency and said first random number;

generating, when said game result is said hit, a second random number;

selecting, when said game result is said hit, a payout from a plurality of payouts, according to a probability distribution of said plurality of payouts and said second random number;

selecting, when said game result is said non-hit, a payout with a zero payout amount;

generating a third random number;

selecting a display from a set of displays which are consistent with the payout rules and said selected payout;

displaying said selected display; and

crediting, when said game result is said hit, the player with a payout amount of said selected payout.

35. The method of claim 34, wherein said probability distribution of said plurality of payouts is independent of a distribution of displays in said set of displays.

BNSDOCID: <WO_____9608295A1_IA>

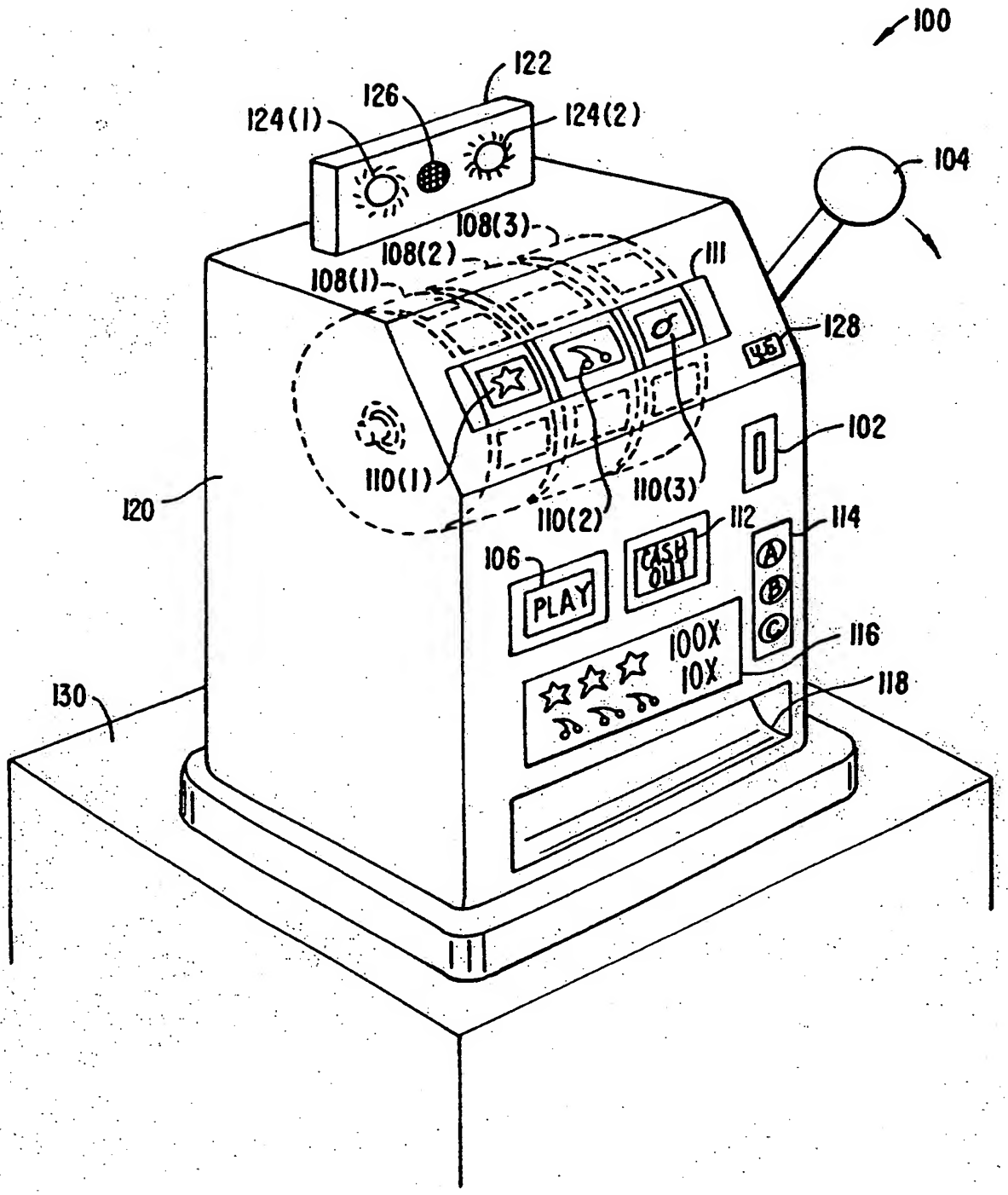

FIG. 1.

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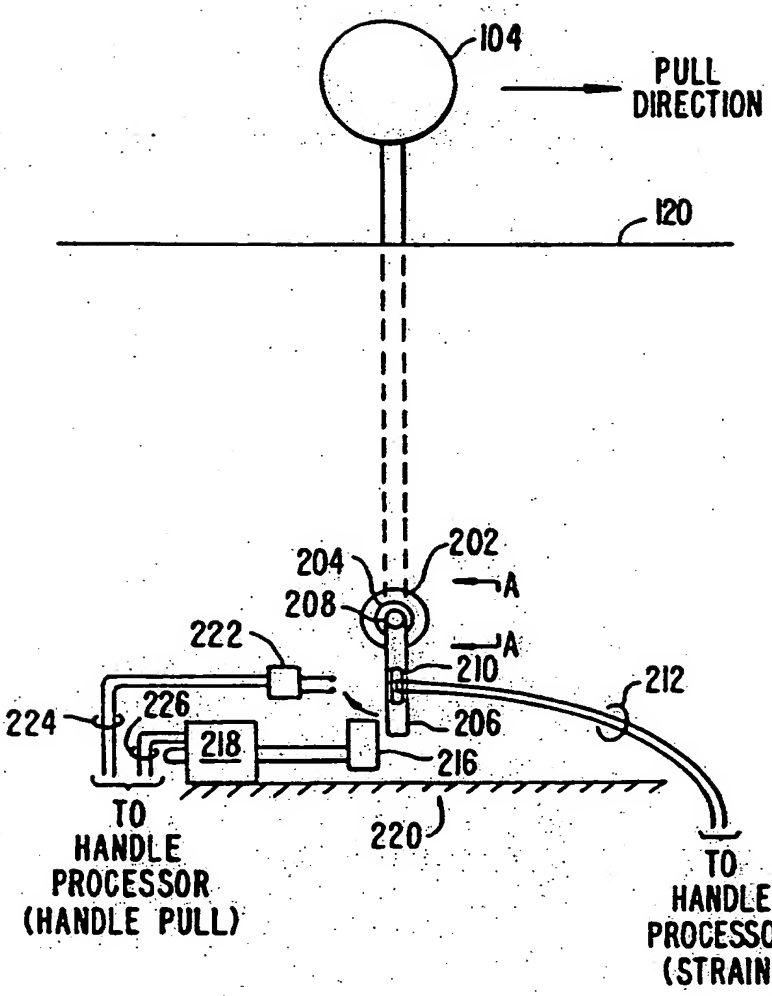

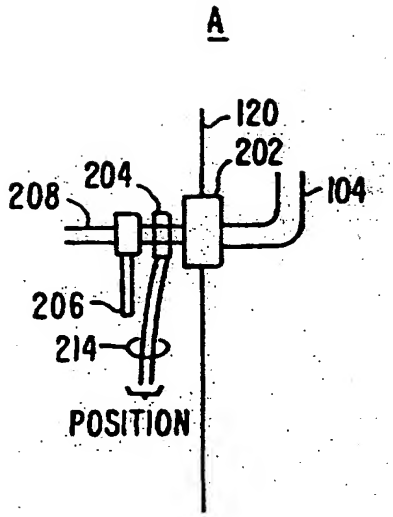

FIG. 2.

BNSDOCID: <WO_____9608295A1_IA>

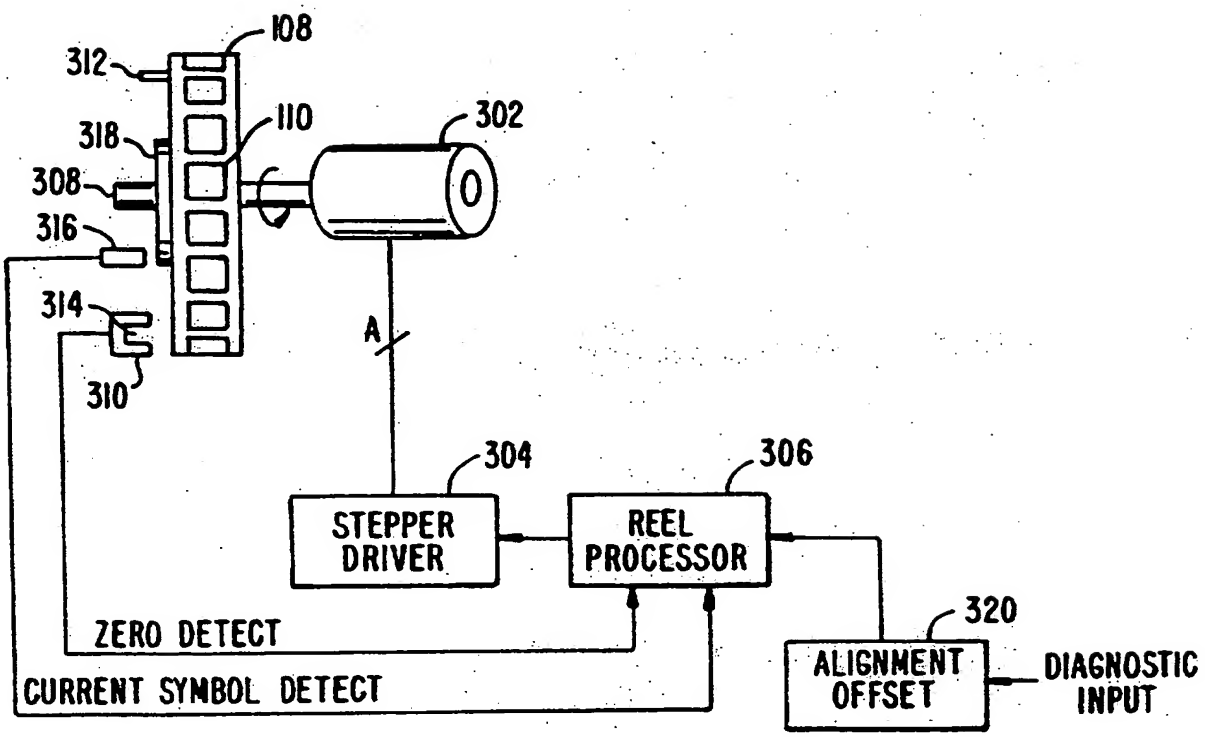

FIG. 3.

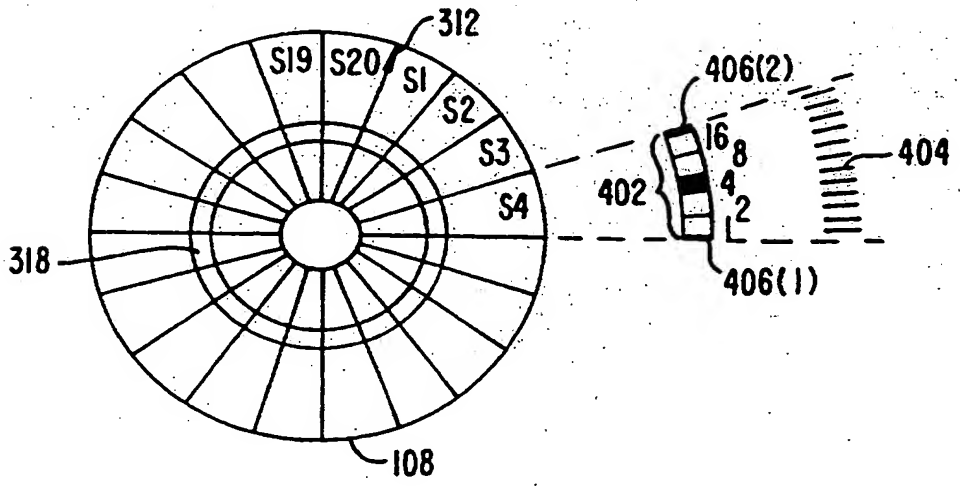

FIG. 4.

BNSDOCID: <WO 9608295A1 IA>

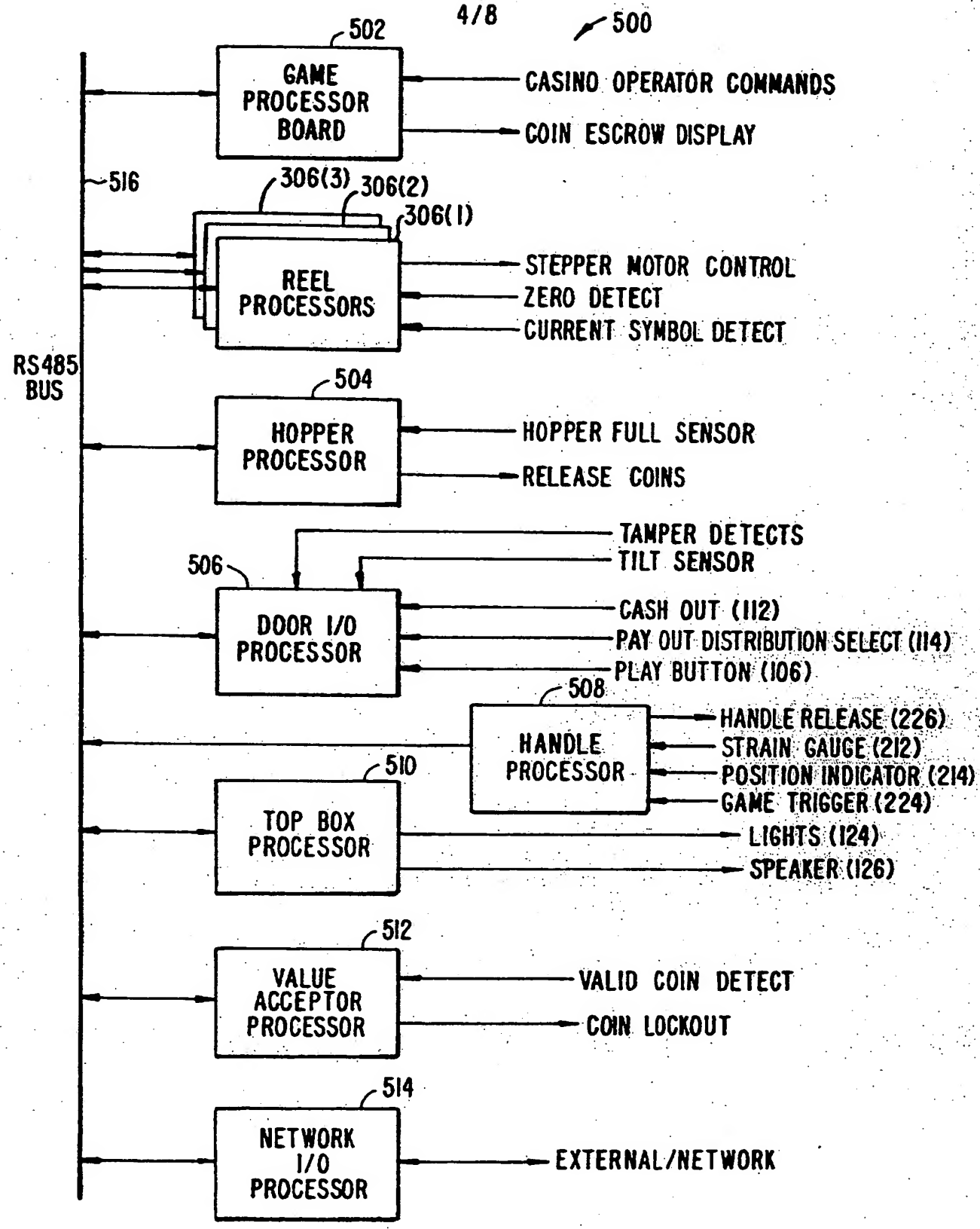

FIG. 5.

BNSDOCID: <WO_____9608295A1_IA>

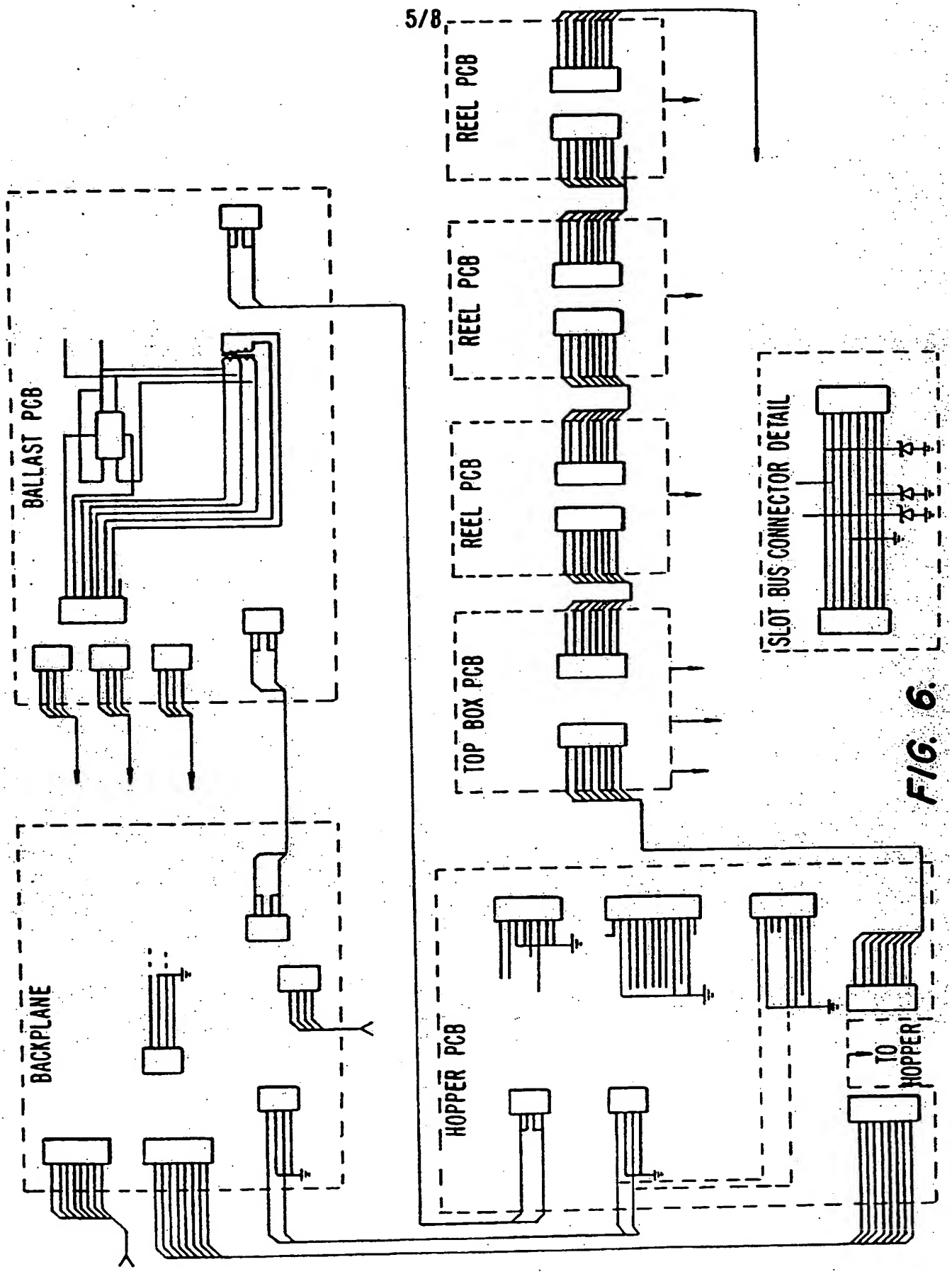
REEL PCB
REEL PCB
REEL PCB
TOP BOX PCB
SLOT BUS CONNECTOR DETAIL
BALLAST PCB
BACKPLANE
HOPPER PCB
TO HOPPER

FIG. 6.

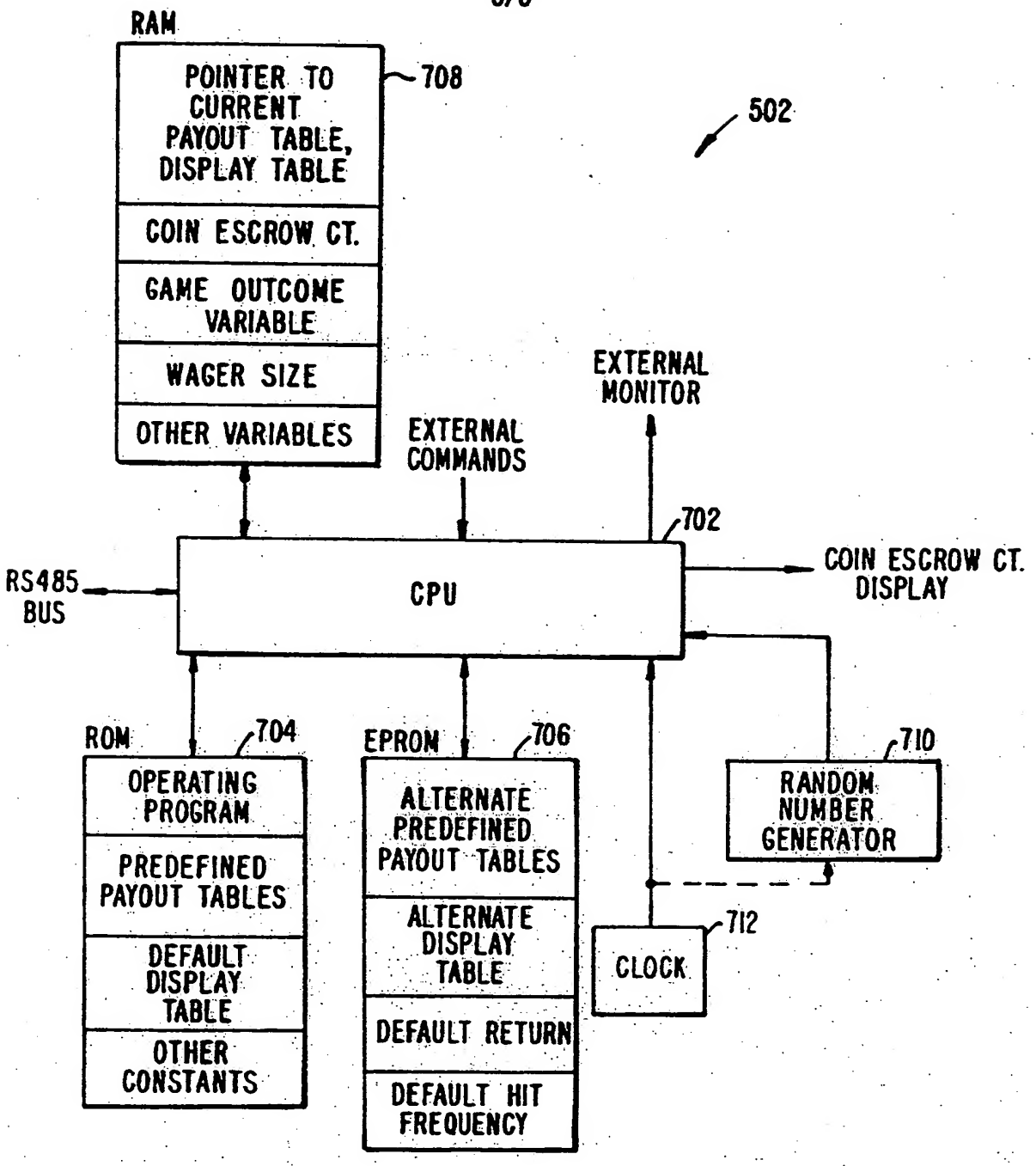

FIG. 7.

BNSDOCID: <WO_____9608295A1_IA>

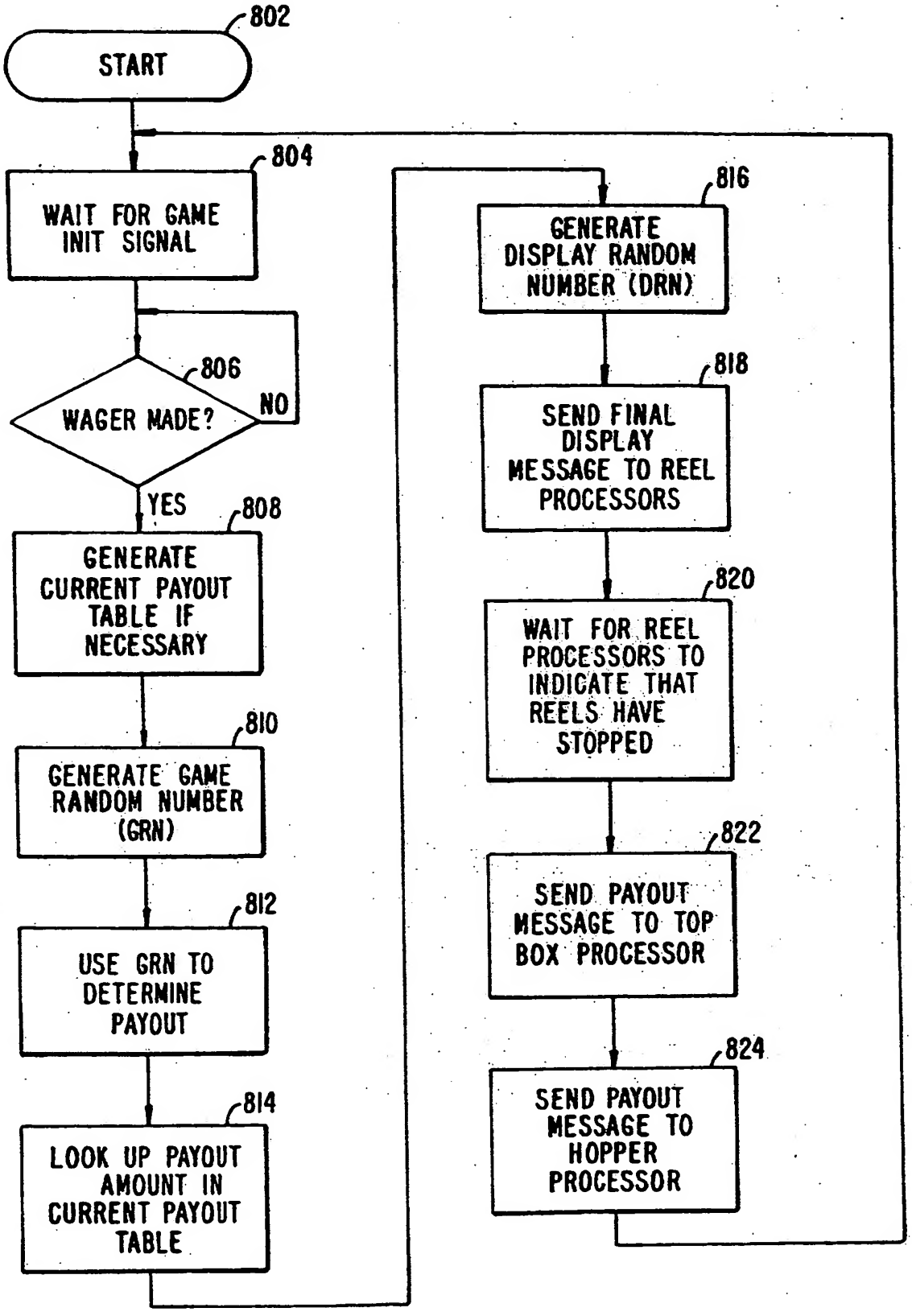
802
START
804
WAIT FOR GAME INIT SIGNAL
806
WAGER MADE?
NO
YES
808
GENERATE CURRENT PAYOUT TABLE IF NECESSARY
810
GENERATE GAME RANDOM NUMBER (GRN)
812
USE GRN TO DETERMINE PAYOUT
814
LOOK UP PAYOUT AMOUNT IN CURRENT PAYOUT TABLE
816
GENERATE DISPLAY RANDOM NUMBER (DRN)
818
SEND FINAL DISPLAY MESSAGE TO REEL PROCESSORS
820
WAIT FOR REEL PROCESSORS TO INDICATE THAT REELS HAVE STOPPED
822
SEND PAYOUT MESSAGE TO TOP BOX PROCESSOR
824
SEND PAYOUT MESSAGE TO HOPPER PROCESSOR

FIG. 8.

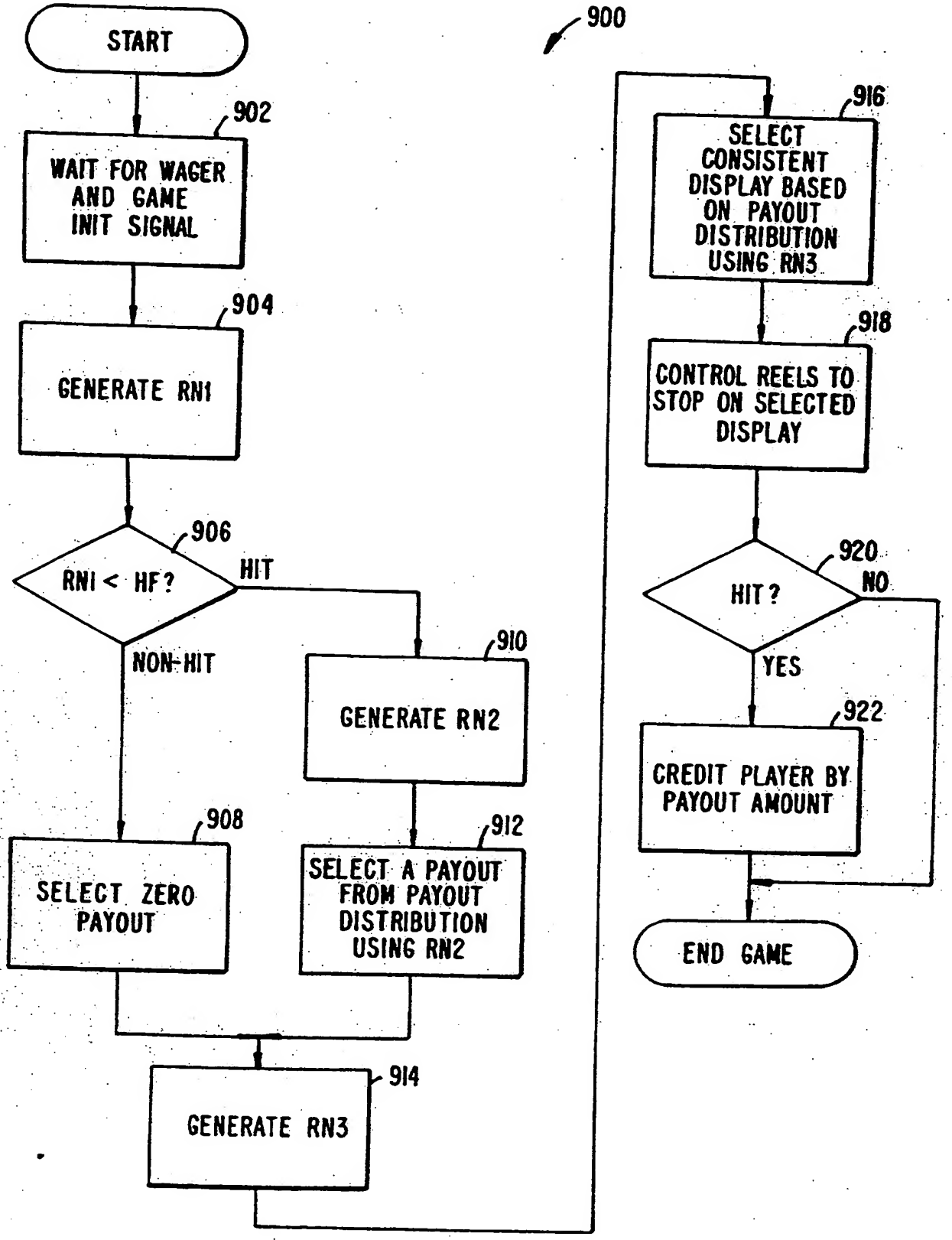

FIG. 9.

BNSDOCID: <WO_____9608295A1_IA>

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/11658

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A63F 1/18
US CL :273/138A, 142R, 143R

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 273/85CP, 85G, 138A, 139, 142R, 143R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 5,074,559 (OKADA) 24 December 1991, see entire document.	21, 23, 31-32 --- 22, 24-26, 28, 29, 33-35
X --- Y	US, A, 4,772,023 (OKADA) 20 September 1988, see entire document.	15-17, 19 --- 1-10, 12-14, 18, 34, 35
Y	US, A, 5,102,136 (HEIDEL ET AL.) 07 April 1992, see entire document.	10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
08 NOVEMBER 1995

Date of mailing of the international search report
01 FEB 1996

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Form PCT/ISA/210 (second sheet)(July 1992)*

RNSDOCID: <WO 9608285A1 IA>

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/11658

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,018,737 (OKADA) 28 May 1991, see entire document.	5, 11
Y	US, A, 4,889,339 (OKADA) 26 December 1989, see column 3 line 46.	3
Y	US, A, 4,817,951 (CROUCH ET AL.) 04 April 1989, see entire document.	24
Y	US, A, 4,790,537 (SMYTH ET AL.) 13 December 1988, see entire document.	12-14
Y	GB, A, 2 200 779 (JPM LIMITED) 10 August 1988, see entire document.	14
Y	EP, A, 0 099 189 (BALLY MANUFACTURING CORPORATION) 25 January 1984, see entire document.	1-7
Y	GB, A, 2 103 856 (JPM LIMITED) 23 February 1983, see entire document.	8-10
Y	US, A, 3,733,076 (OHKI) 15 May 1973, see Figs. 1, 2 and 5.	18

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